U.S. DEPARTMENT OF COMMERCE
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PB-280 369

Proposed Issuance of a New Source National Pollutant Discharge Elimination System Permit Number IA-0060909 to Iowa Southern Utilities Company, Ottumwa Generating Station for Discharge of Wastewaters to the Des Moines River near Ottumwa, Iowa

Environmental Protection Agency, Kansas City, Mo. Region VII

Jul 77

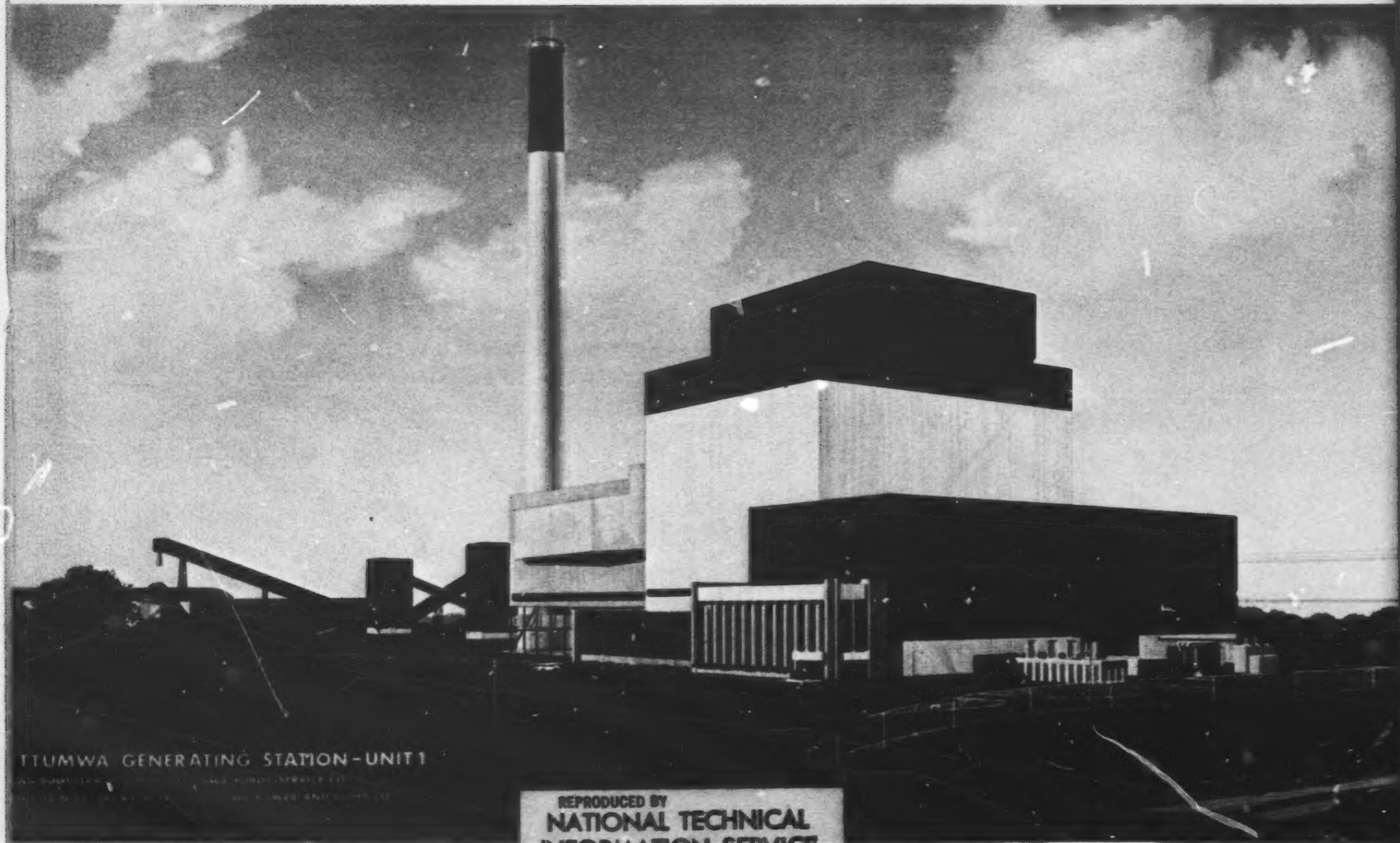
EPA-907/9-77-004

EPA-7-IA-Ottumwa-Wapello-NSDP-77

PB 280 369

Draft Environmental Impact Statement

Ottumwa Generating Station
IOWA SOUTHERN UTILITIES COMPANY



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U. S. ENVIRONMENTAL PROTECTION AGENCY
Region VII, Kansas City, Missouri

July 1977

EPA-7-IA-Ottumwa-Wapello-NSDP-77
DEIS 004
NPDES Permit Number IA-0060909
July 1977

DRAFT ENVIRONMENTAL IMPACT STATEMENT

On Proposed Issuance of a New Source National Pollutant Discharge Elimination System Permit Number IA-0060909 to

IOWA SOUTHERN UTILITIES COMPANY OTTUMWA GENERATING STATION

For Discharge of Wastewaters to the Des Moines River near Ottumwa, Iowa

prepared by
U. S. Environmental Protection Agency
Region VII, Kansas City, Missouri

in conjunction with
U. S. Army Corps of Engineers
Rock Island, Illinois, District

with technical assistance by
Black & Veatch Consulting Engineers
Kansas City, Missouri

approved by

Charles V. Wright June 28, 1977
Acting Regional Administrator (date)

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

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1735 Baltimore
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Prepared in conjunction with U.S.Army Engineers, Rock Island, Illinois District

16. ABSTRACT
The U.S. Environmental Protection Agency (EPA) is considering the issuance of a new source National Pollutant Discharge Elimination System (NPDES) permit (P.L. 92-500, Section 402) for discharge of wastewaters from Iowa Southern Utilities' proposed Ottumwa Generating Station (OGS). Pursuant to the National Environmental Policy Act of 1969 (P.L. 91-190), EPA has prepared this environmental impact statement (EIS) to evaluate the potential impacts of this action on the Des Moines River, the cities of Chillicothe and Ottumwa, and the surrounding areas. This EIS is a multiagency document prepared in conjunction with the U.S. Army Corps of Engineers. It will serve as the Corps of Engineers' EIS in the issuance of a Section 404, Federal Water Pollution Control Act Amendments permit and a Section 10, River and Harbors Act permit.

The proposed site for the 727 megawatt coal-fired steam-electric generating station is located adjacent to the Des Moines River approximately 8 miles northwest of Ottumwa, Iowa. Its estimated cost is $300 million.

OGS will utilize a closed-cycle cooling system and will require make-up water at a rate of 17 cfs at maximum load conditions. Total discharge to the Des Moines River is estimated to be 1.4 cfs at maximum load conditions. Low sulfur western coal will fuel the plant at a rate of 2,200,000 tons per year. Principal constituents of the plant stack emissions are particulate matter, sulfur oxides, nitrogen oxides and →

17. KEY WORDS AND DOCUMENT ANALYSIS

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		go to p ia

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various trace elements. An electrostatic precipatator will be used to control particulate matter. Selection of low sulfur coal will minimize SO_2 emissions, and furnace design will control NO_2.

ia

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII
1735 BALTIMORE
KANSAS CITY, MISSOURI 64108

TO: ALL INTERESTED GOVERNMENTAL AGENCIES, PUBLIC GROUPS, AND CITIZENS

Enclosed with this notice is a copy of the Draft Environmental Impact Statement (EIS) for the Ottumwa Generating Station. This document is submitted for your review and comment pursuant to Section 102(2)(c) of the National Environmental Policy Act of 1969 (Public Law 91-190). All comments submitted to this agency on the Draft EIS and EPA's responses will be incorporated into the Final EIS.

The principal owner of the power plant, Iowa Southern Utilities Company, has applied for Environmental Protection Agency and U.S. Army Corps of Engineers permits. This document serves as the EIS for these two agencies and will be used to evaluate the environmental impacts of their actions.

Comments should be submitted to this office within 45 days of the date the President's Council on Environmental Quality publishes notice of the EIS in the Federal Register.

Additional copies of this statement are available for review in the EPA Region VII Library and the Ottumwa Public Library, Ottumwa, Iowa. Please direct your comments to:

U.S. Environmental Protection Agency
Region VII
1735 Baltimore
Kansas City, Missouri 64108

We appreciate the time and effort you will spend in reviewing the EIS.

Sincerely yours,

Earl J Stephenson

for Charles V. Wright
Acting Regional Administrator

Enclosure

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SUMMARY

OTTUMWA GENERATING STATION

(X) DRAFT ( ) FINAL

RESPONSIBLE OFFICE: U.S. Environmental Protection Agency, 1735 Baltimore, Kansas City, Missouri 64108, telephone 816-374-2921.

1. Name of Action: (X) Administrative ( ) Legislative

2. Description of Action and Proposed Project: The U.S. Environmental Protection Agency (EPA) is considering the issuance of a new source National Pollutant Discharge Elimination System (NPDES) permit (P.L. 92-500, Section 402) for discharge of wastewaters from Iowa Southern Utilities' proposed Ottumwa Generating Station (OGS). Pursuant to the National Environmental Policy Act of 1969 (P.L. 91-190), EPA has prepared this environmental impact statement (EIS) to evaluate the potential impacts of this action on the Des Moines River, the cities of Chillicothe and Ottumwa, and the surrounding areas. This EIS is a multiagency document, prepared in conjunction with the U.S. Army Corps of Engineers. It will serve as the Corps of Engineers' EIS in the issuance of a Section 404, Federal Water Pollution Control Act Amendments permit and a Section 10, River and Harbors Act permit.

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3. Environmental Impacts: The Des Moines River will be impacted by water withdrawl and discharge of wastewaters. This wastewater consists of effluents from plant wastewater treatment systems and sanitary waste treatment systems. Runoff from the coal pile will also be discharged. Approximately 795 acres of agricultural land and wildlife habitat will be converted to industrial use. Local populations will have higher noise levels and air pollution to contend with.

Unavoidable Adverse Environmental Effects: Noise and dust during construction activities will be a temporary impact. Levels of SO_2, NO_x, ozone, and particulate matter will increase. Damage or death of aquatic organisms will result from their impingement on the intake structure and entrainment into the circulating water system during plant operation.

4. Alternatives: The alternatives available to EPA include: (1) issuance of a new source NPDES permit; (2) issuance of a conditional new source NPDES permit, or a NPDES permit for a modified facility, (3) denial of a new source NPDES permit (no action).

Alternatives considered in this EIS include: (1) no action; (2) purchase of power; (3) conservation of energy; (4) alternate fuel sources; (5) facility sites; (6) facility design variations.

5. Comments Requested:

Federal Agencies

Council on Environmental Quality
U.S. Department of Agriculture
    Forest Service
    Soil Convervation Service
U.S. Department of Commerce
U.S. Department of Health, Education, and Welfare
U.S. Department of Housing and Urban Development
    Regional Administrator, Region VII
    Area Director
U.S. Department of the Interior
U.S. Department of Transportation
    Federal Highway Administration
    Federal Aviation Administration
    Coast Guard
Federal Power Commission
Advisory Council on Historic Preservation
Water Resource Council
Federal Energy Administration
Upper Mississippi River Basin Commission

Members of Congress

Richard Clark, U.S. Senator
John C. Culver, U.S. Senator
James Leach, U.S. House of Representatives
Neal Smith, U.S. House of Representatives

State

A-95 Federal Funds Coordinator
Gene Glenn, State Senator
Forrest Schengels, State Senator
Mattie Harper, State Representative
Floyd H. Miller, State Representative
Charles N. Poncy, State Representative
Iowa Department of Environmental Quality
Iowa State Conservation Commission
State Historical Department
State Library Commission of Iowa

Local and Regional

Mayor, Chillicothe, Iowa
Mayor, Ottumwa, Iowa
Area XI Regional Planning Commission
Area XV Regional Planning Commission
Iowa Association of Soil Conservation District Commissioners
State Association of County Conservation Boards

Interested Groups and Individulas

National Forest Products Association
Iowa Coal Project
St. Louis University
Iowa State University
University of Iowa
Fluor Pioneer Company
Iowa Association of Municipal Utilities
Iowa Academy of Science
Iowa Wildlife Federation
Indian Hills Community College
Iowa Ornithologists' Union
Iowa Conservation Education Council, Inc.
Iowa Confederation of Environmental Organizations
League of Women Voters of Iowa
Nature Conservancy, Iowa Chapter
Sierra Club, Iowa Chapter
State Preserves Board
J.N. "Ding" Darling Foundation, Inc.
Environmental Coordinating Council
Izaak Walton League of America, Iowa Division
Keep Earth's Environment Pure
Calhoun County Environmental Action
Audubon Society, Des Moines Chapter
Society of American Foresters
National Audubon Society
Wildlife Society
Iowa Commercial Fisheries Association
Ducks Unlimited
National Resources Council
Environmental Coordinating Council
Environmental Law Society
Citizens United for Responsible Energy
People's Energy Project
Citizens for Environmental Action
Community Action Research Group
Jim Crane
Scott Jones
Chuck Steffen

GLOSSARY

Adjusted Net Capability--The net buying and generating capacity for the system as a whole.

Adjusted Net Capacity--Refers to the rating of a single generator.

Aquifer--A stratum or zone below the surface of the earth capable of transporting and storing water. The water usually flows through pores or cracks in the rock.

Ash--The solid residue following combustion of a fuel.

Ash Sluice--The transport of solid residue ash by water flow in a conduit.

Base Load--The minimum load over a given period of time.

Benthic--As related to benthos, plant or animal organisms attached or resting on the bottom or living in the bottom sediments of a freshwater body.

Biota--The plant and animal life of a given locale, area, or region.

Block Rate--A type of metered rate. A certain specified price per unit is charged for all or any part of a block of units, and reduced prices per unit are charged for all or any part of succeeding blocks of such units, each such reduced price per unit applying only to a particular block or portion thereof.

Blowdown--A portion of water in a closed system which is wasted in order to prevent a build-up of dissolved solids.

BOD--Biochemical oxygen demand. The BOD value represents the amount of oxygen required by bacteria to decompose aerobically an amount of organic matter in a given period of time at a stated temperature.

Bottom Ash--The solid residue left from the combustion of a fuel, which falls to the bottom of the combustion chamber.

cfs--cubic feet per second. The rate of flow of a measured volume of water.

Circulating Water System--A system which conveys cooling water from its source to the main condensers and then to the point of discharge. Synonymous with cooling water system.

Cooling Tower--A configured heat exchange device which transfers reject heat from circulating water to the atmosphere.

Copepods--A zooplankton form.

DDT--Dichlorodiphenyltrichloroethane, an insecticide classified as a chlorinated hydrocarbon or organochlorine.

Demand Rate--Any method of charge for electric service which is based upon or is a function of the rate of use, or size, of the customer's installation or maximum demand (expressed in kilowatts, kilovoltamperes, or horsepower) during a given period of time.

Derivative Effect--The investment of funds, equipment, and manpower during the creation or expansion of productive facilities generates a multiple expansion of employment and of related income. This multiple expansion is called "the multiplier effect."

Diatom--A principal type of algae whose cell walls consist of two boxlike parts or valves that contain silica.

Discharge--To release or vent.

Ecosystem--Any area of nature that includes organisms and nonliving substances interacting to produce an exchange of materials between the living and nonliving parts.

Environment--All the conditions, circumstances and influences surrounding and affecting the development of an organism or group of organisms.

Electrostatic Precipitator--A device for removing particles from a stream of gas based on the principle that these particles carry electrostatic charges and can therefore be attracted to an electrode by imposing a potential across the stream of gas.

Embankment--The non-concrete portion of the dam, consisting of compacted earthen materials.

Epicenter--The area of the earth's surface directly above the place of origin, or focus, of an earthquake.

Fauna--Refers to all animal species found in an area.

Flat Rate--A type of demand rate. A charge for electric service based upon the customer's installation of energy-consuming devices. This is usually so much per watt, per kilowatt, or per horsepower, per month or per year. Sometimes this type of rate is nominally so much per customer per year, or per month, for each of various classes of customers, but estimated demand and quantity of energy likely to be used play an important part in the determination of the class.

Flora--Refers to all the plant species found in an area.

Flue Gas--The gaseous products resulting from the combustion process after passage through the boiler.

Fly Ash--A portion of the non-combustible residue from a fuel which is carried out of the boiler by the flue gas.

fps--feet per second.

gpm--gallons per minute.

Habitat--The place where a given species lives, generally the kind of place rather than a geographic location.

Heptachlor--A biocide classified as a chlorinated hydrocarbon.

Herbaceous--Of, or having the nature of an herb; like a green leaf in texture, color, and shape.

Herbivores--Primary consumer organisms that feed directly on living plants or plant remains.

Kilowatt(kW)--1000 watts.

Kilowatt-hour (kWh)--The basic unit of electric energy equal to 1 kilowatt of power supplied to or taken from an electric circuit steadily for 1 hour.

Lentic--Standing water conditions such as lakes, ponds, or swamps.

Load--The amount of electric power delivered or required at any specified point or points on a system. Load originates primarily at the power consuming equipment of the customers.

Load Center--A point at which the load of a given area is assumed to be concentrated.

Meter Rate--Any method of charge for electric service based solely upon quantity, such as kilowatt-hours used.

Multiplier Effect--Synonymous with derivative effect.

Periphyton--Freshwater organisms (both plant and animal) attached or clinging to stems and leaves of rooted plants or other surfaces projecting above the bottom.

Phytoplankton--Producer organisms. Minute floating plants, usually called algae, distributed throughout the pond as deep as light penetrates. In abundance, the phytoplankton gives the water a greenish color; otherwise, they are not visible to the observer.

Plankton Communities--Floating, microscopic (plant and animal) organisms whose movements are more or less dependent on currents.

Primary Succession--Succession developing on an area which has not been previously occupied by a community (such as newly exposed rock or sand surface).

Regeneration--Displacement from ion exchange resins of the ions removed from the process solution.

Regional Econometric Model--A computerized, empirical model which describes a regional economy based on historical economic interrelationships. The specification of economic relationships in the model's equations are based on economic theory and experimental testing.

Rotifer--A zooplankton form.

Secondary Succession--Community development proceeding in an area from which a community was removed (such as a plowed field or cutover forest).

Service Area--Territory in which a utility system is required or has the right to supply electric service to ultimate customers.

Sludge--Accumulated solids separated from a liquid during processing.

Steam Generating Station--An electric generating station in which the prime mover is a steam turbine. The steam is generated in a boiler by heat burning from fossil fuels.

Steam Generator--The equipment which uses a heat source to change water into steam.

Steam Turbine--An enclosed rotary type of prime mover in which heat energy in steam is converted into mechanical energy by the force of high velocity flow of steam directed against successive rows of radial blades fastened to a central shaft.

Succession--The orderly and progressive replacement of one community by another until a relatively stable community occupies the area.

Terrestial--Referring to organisms (plant and animal) that live on land as opposed to those that live in water.

Uplands--Refers to habitat and associated species in the upper (land) elevations of the project, as opposed to that found within the flood plain.

Zooplankton--Consumer organisms. Minute animal plankton; a type of herbivore.

I PROJECT DESCRIPTION

1.01 Introduction. Iowa Southern Utilities Company (ISU) and three other utility companies propose to jointly construct and operate a coal-fired steam-electric generating plant on a site located in Wapello County, Iowa about 8 miles northwest of Ottumwa at approximately River Mile 106 on the Des Moines River. The location of the Ottumwa Generating Station (OGS) is shown on Figure 1-1 and ISU's service area is shown in Figure 1-2.

1.011 The participating companies and their per cent ownership of the proposed facility are shown in Table 1-1.

Table 1-1

OWNERS OF THE OTTUMWA GENERATING STATION-UNIT 1

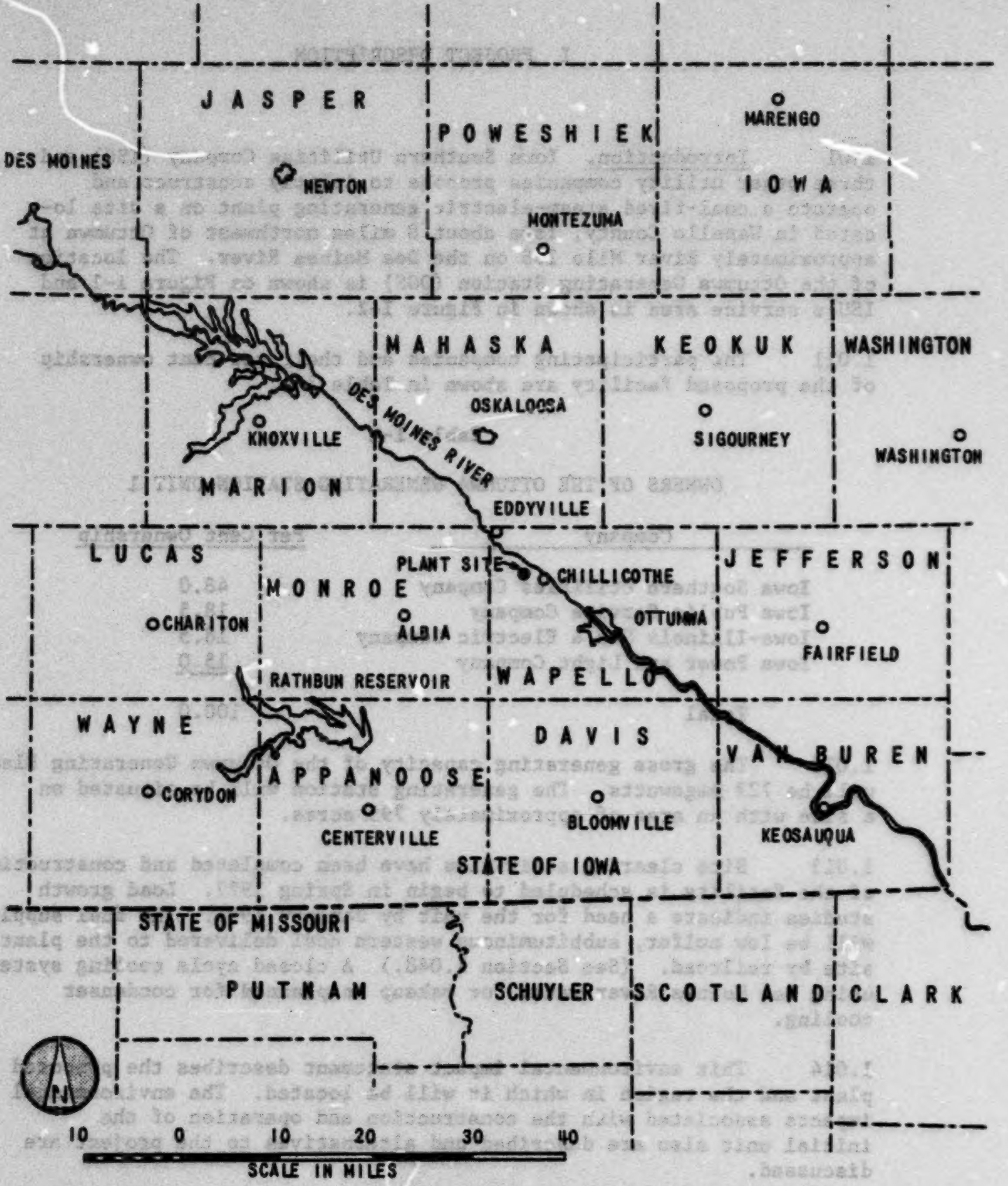
Company	Per Cent Ownership
Iowa Southern Utilities Company	48.0
Iowa Public Service Company	18.5
Iowa-Illinois Gas & Electric Company	18.5
Iowa Power and Light Company	15.0
Total	100.0

1.012 The gross generating capacity of the Ottumwa Generating Plant will be 727 megawatts. The generating station will be situated on a site with an area of approximately 795 acres.

1.013 Site clearing activities have been completed and construction of the facility is scheduled to begin in Spring 1977. Load growth studies indicate a need for the unit by January 1981. The fuel supply will be low sulfur, subbituminous western coal delivered to the plant site by railroad. (See Section 1.048.) A closed cycle cooling system using Des Moines River water for makeup is planned for condenser cooling.

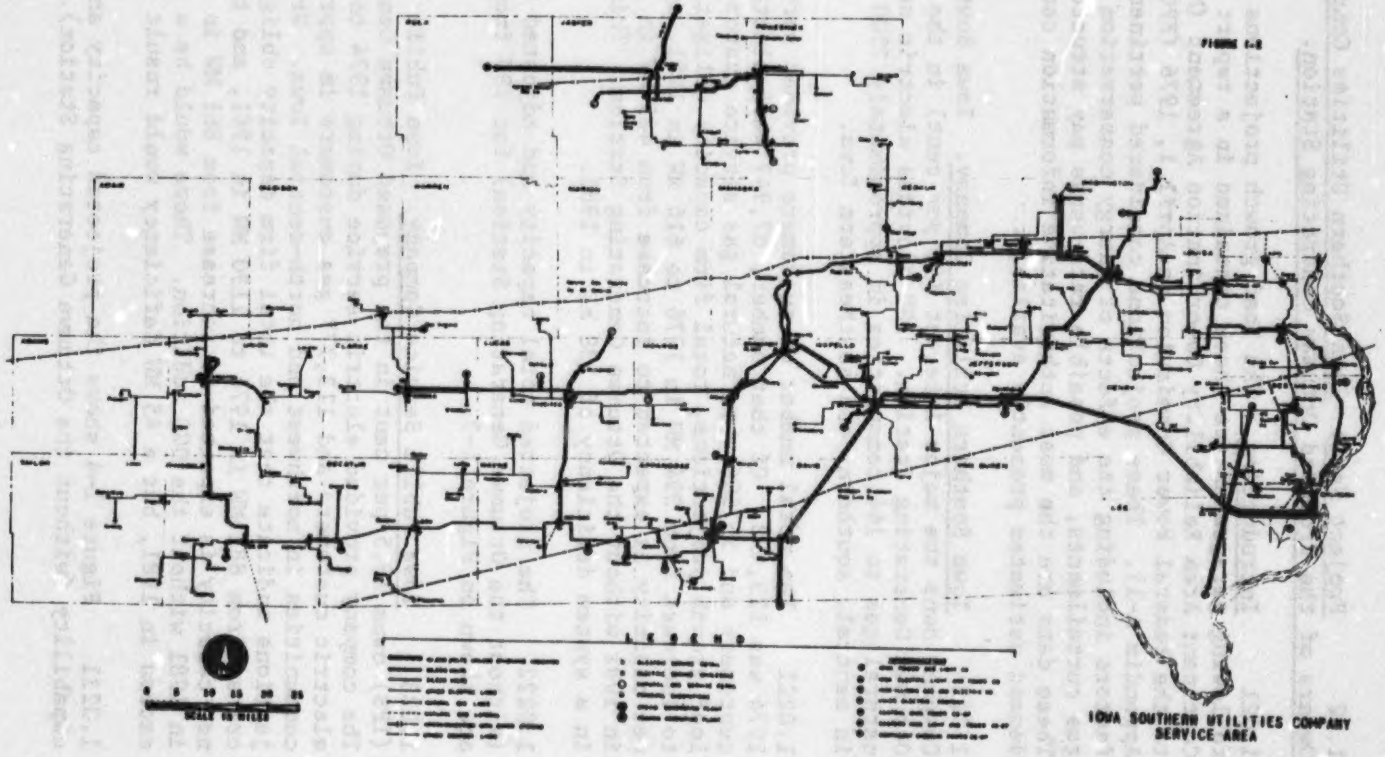
1.014 This environmental impact statement describes the proposed plant and the region in which it will be located. The environmental impacts associated with the construction and operation of the initial unit also are described and alternatives to the project are discussed.

FIGURE I-1



LOCATION OF THE OTTUMWA GENERATING STATION

FIGURE I-2


LEGEND
IOWA SOUTHERN UTILITIES COMPANY
SERVICE AREA
SCALE IN MILES
0 5 10 15 20 25

1.02 Project Need: Iowa Southern Utilities Company and Other Owners of the Proposed Ottumwa Generating Station.

1.021 Introduction. The load growth projections presented in the following paragraphs are those contained in a report by the Mid-Continent Area Reliability Co-ordination Agreement (MARCA) submitted to the Federal Power Commission on April 1, 1976 (FPC Docket R362, Appendix A-1). These projections considered pertinent influencing factors including the effects of energy conservation efforts, natural gas curtailments, and possible rate-usage pay structure changes. These data are the most authoritative information concerning energy demand estimates presently available.

1.022 Iowa Southern Utilities Company. Iowa Southern Utilities Company owns the major interest (48 per cent) in the proposed Ottumwa Generating Station. ISU provides electric service and natural gas to 164 communities in approximately 7500 square miles in central, southern, and southeastern Iowa.

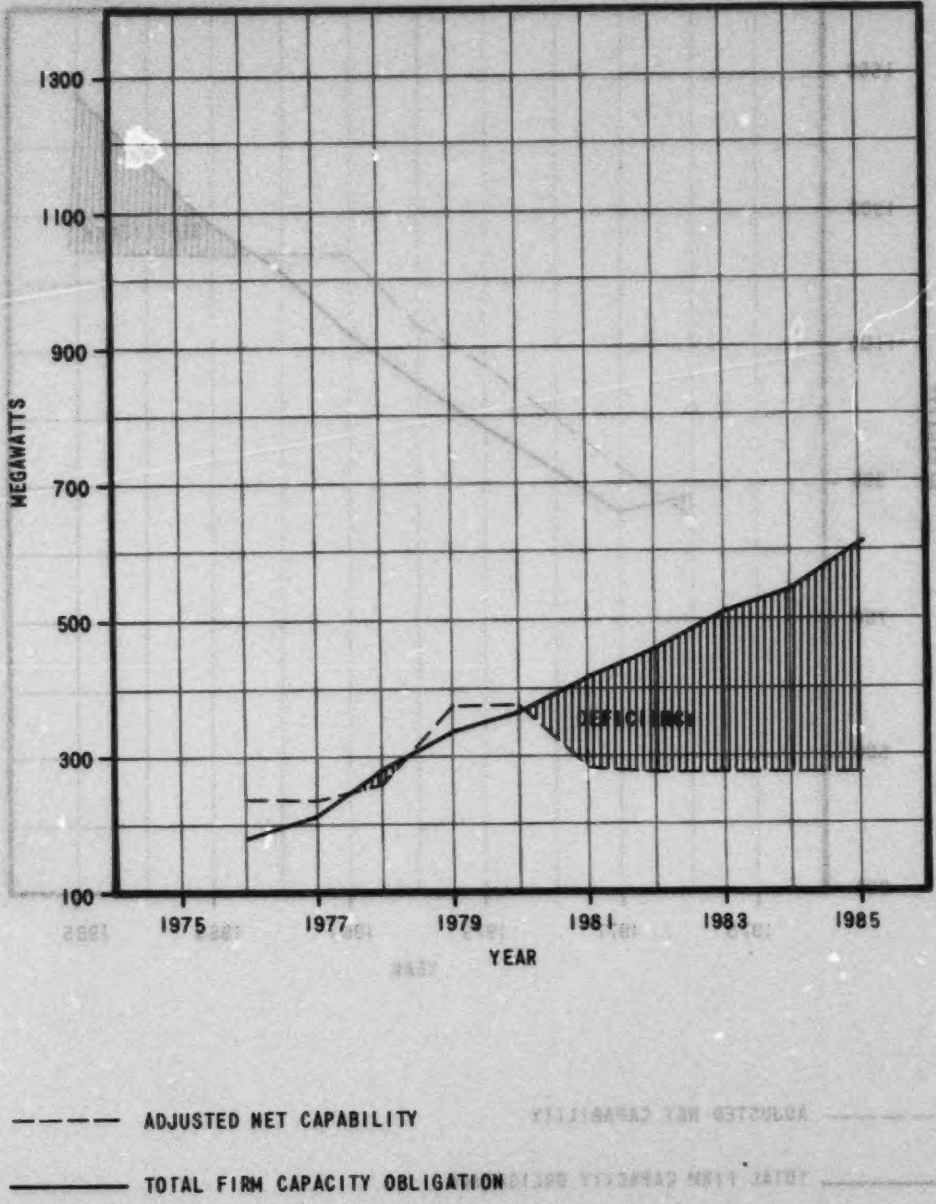
1.0221 The total number of customers provided service by ISU in 1974 was 123,453. Of that number, 87,947 were electric service customers and 35,506 were natural gas service customers. Based on load growth projections, total firm capacity obligation is expected to increase from 394 MW in 1976 to 616 MW in 1981, and the adjusted net capacity is expected to increase from 425 MW in 1976 to 478 MW in 1981 without the Ottumwa Generating Station. This would result in a system deficiency of 138 MW in 1981.

1.0222 The projected total capacity and adjusted net capability (without the Ottumwa Generating Station) for ISU from 1976 to 1985 are shown on Figure 1-3.

1.023 Iowa Public Service Company. Iowa Public Service Company (IPS) owns 18.5 per cent in the proposed Ottumwa Generating Station. The company provided electric service during 1974 to about 145,549 electric customers and 113,777 gas customers in approximately 323 communities in northwest and north-central Iowa. Growth load projections indicate that the total firm capacity obligation will increase from 881 MW in 1976 to 1130 MW in 1981, and that the adjusted net capacity is expected to increase from 861 MW in 1976 to 1246 MW in 1981 without the OGS addition. There would be a 116 MW system excess in 1981, but a 45 MW deficiency would result by 1983.

1.0231 Figure 1-4 shows the projected capacity and adjusted net capability (without the Ottumwa Generating Station).

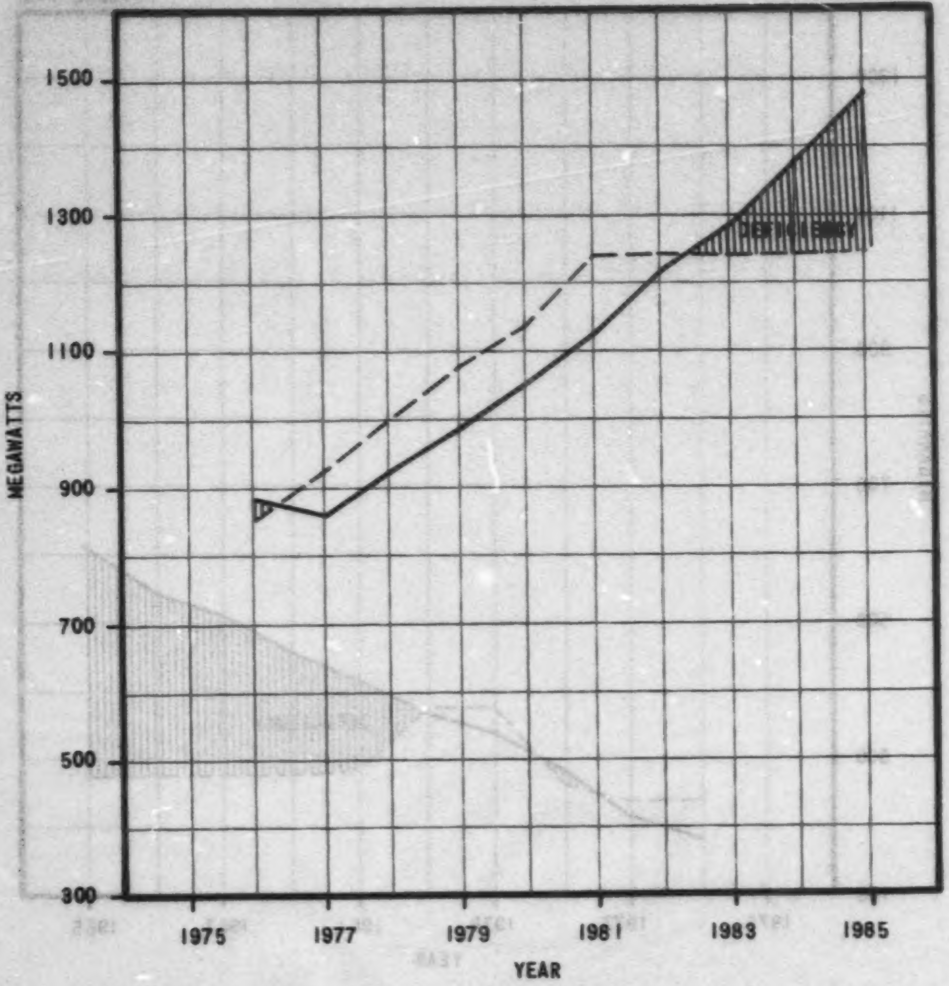
FIGURE I-3



SOURCE: REPORT BY MID-CONTINENT AREA RELIABILITY CO-ORDINATION AGREEMENT (MARCA) TO FEDERAL POWER COMMISSION, FPC DOCKET R362, APPENDIX A-1, APRIL 1, 1976.

PROJECTED TOTAL FIRM CAPACITY OBLIGATION AND ADJUSTED NET CAPABILITY OF IOWA SOUTHERN UTILITIES COMPANY - 1976-1985

FIGURE I-4



– – – – ADJUSTED NET CAPABILITY

———— TOTAL FIRM CAPACITY OBLIGATION

SOURCE: REPORT BY MID-CONTINENT AREA RELIABILITY CO-ORDINATION AGREEMENT (MARCA) TO FEDERAL POWER COMMISSION, FPC DOCKET R362, APPENDIX A-I, APRIL I, 1976.

PROJECTED TOTAL FIRM CAPACITY OBLIGATION AND ADJUSTED NET CAPABILITY OF IOWA PUBLIC SERVICE COMPANY - 1976-1985

1.024 Iowa-Illinois Gas & Electric Company. A total of 18.5 per cent of the proposed generating station is owned by Iowa-Illinois Gas & Electric Company. In 1974 the Company provided electric service to 153,279 customers and natural gas to 197,102 customers.

1.0241 Based on projected sales and other commitments, the total firm capacity requirement will increase from 1015 MW in 1976 to 1413 MW in 1981, and the adjusted net capability is expected to increase from 1082 MW in 1976 to 1285 MW in 1981 without the OGS addition. This results in a system deficiency of 128 MW in 1981.

1.0242 The projected total firm capacity obligation and adjusted net capability for the company (without the Ottumwa Generating Station) for the period 1976 through 1985 are shown on Figure 1-5.

1.025 Iowa Power and Light Company. Iowa Power and Light Company owns 15 per cent of the Ottumwa Generating Station. There are 206,000 electric and 127,000 gas customers (1975), within the company's 5600 square mile service area which includes 202 communities.

1.0251 Base load projections show that the total firm capacity obligation of the company will increase from 1160 MW in 1976 to 1556 MW in 1981. Adjusted net capability is expected to increase from 1218 MW in 1976 to 1502 MW in 1981 without OGS. Without OGS the resulting system deficiency is 54 MW in 1981.

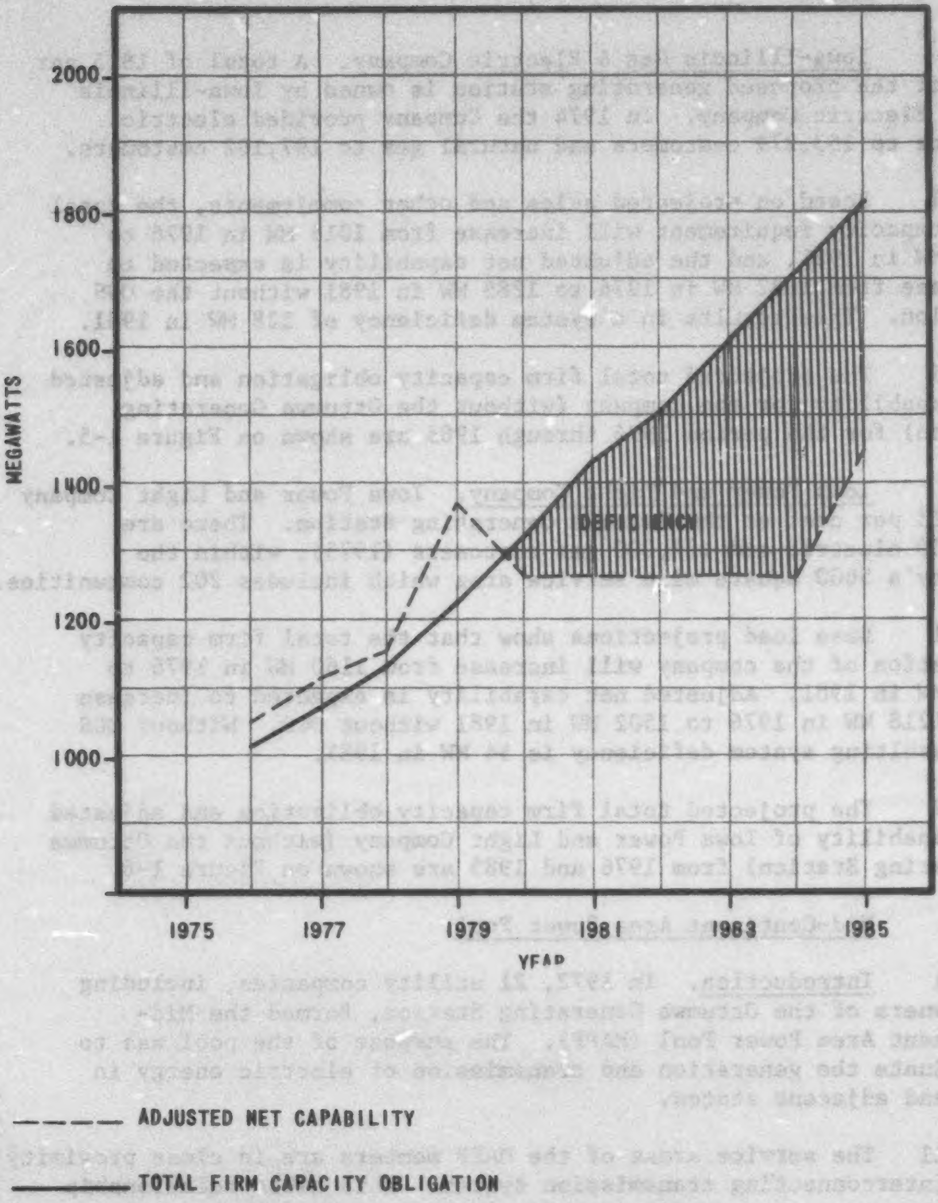
1.0252 The projected total firm capacity obligation and adjusted net capability of Iowa Power and Light Company (without the Ottumwa Generating Station) from 1976 and 1985 are shown on Figure 1-6.

1.026 Mid-Continent Area Power Pool.

1.0261 Introduction. In 1972, 21 utility companies, including the owners of the Ottumwa Generating Station, formed the Mid-Continent Area Power Pool (MAPP). The purpose of the pool was to coordinate the generation and transmission of electric energy in Iowa and adjacent states.

1.02611 The service areas of the MAPP members are in close proximity with interconnecting transmission system. This close relationship contributes to the coordination of planning, construction, and operational activities. The members of MAPP are shown in Table 1-2.

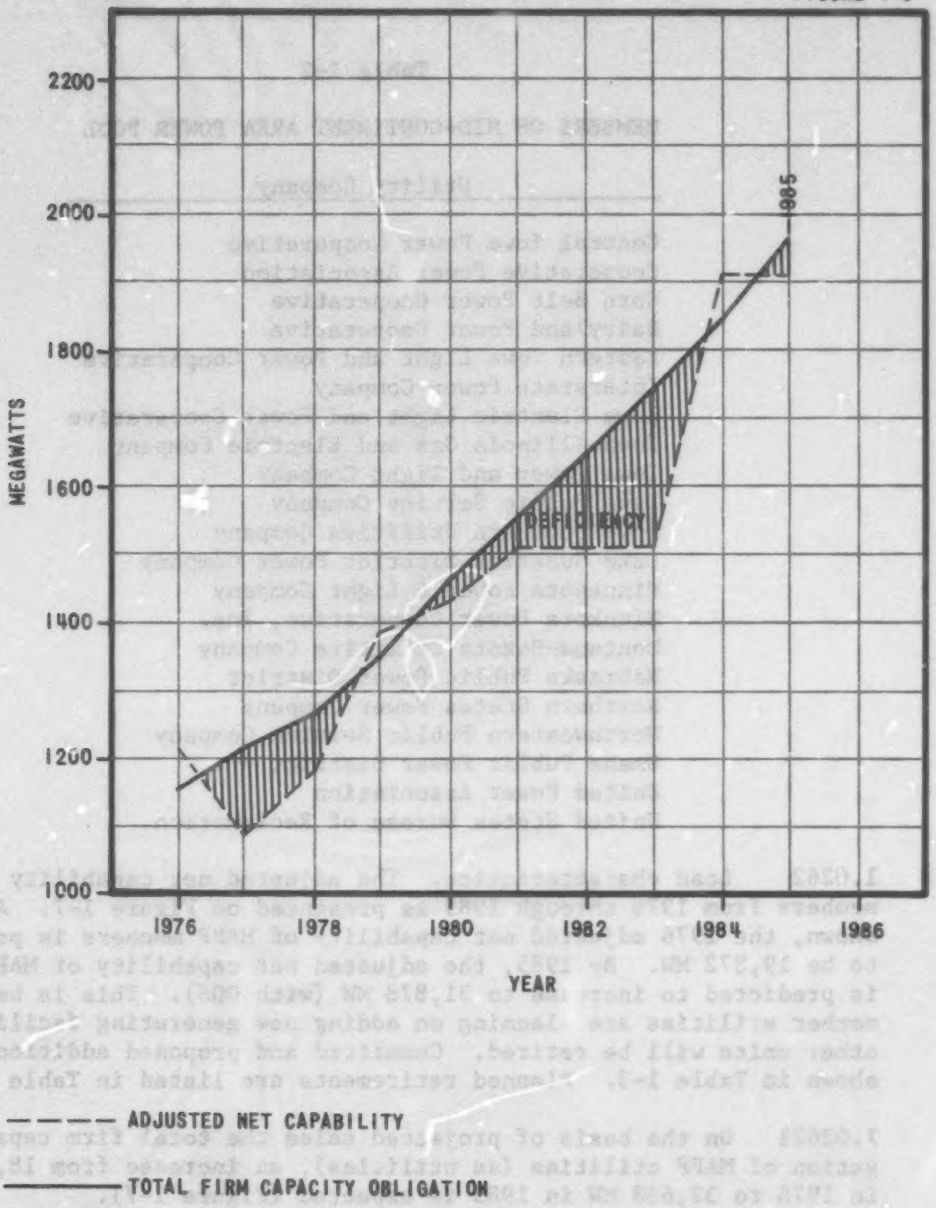
FIGURE I-5



SOURCE: REPORT BY MID-CONTINENT AREA RELIABILITY CO-ORDINATION AGREEMENT (MARCA) TO FEDERAL POWER COMMISSION, FPC DOCKET R362, APPENDIX A-I, APRIL 1, 1976.

PROJECTED TOTAL FIRM CAPACITY OBLIGATION AND ADJUSTED NET CAPABILITY OF IOWA-ILLINOIS GAS & ELECTRIC COMPANY - 1976-1985

FIGURE I-6



SOURCE: REPORT BY MID-CONTINENT AREA RELIABILITY CO-ORDINATION AGREEMENT (MARCA) TO FEDERAL POWER COMMISSION, FPC DOCKET R362, APPENDIX A-1, APRIL 1, 1976.

PROJECTED TOTAL FIRM CAPACITY OBLIGATION AND ADJUSTED NET CAPABILITY OF IOWA POWER AND LIGHT COMPANY - 1976-1985

Table 1-2

MEMBERS OF MID-CONTINENT AREA POWER POOL

Utility Company
Central Iowa Power Cooperative
Cooperative Power Association
Corn Belt Power Cooperative
Dairyland Power Cooperative
Eastern Iowa Light and Power Cooperative
Interstate Power Company
Iowa Electric Light and Power Cooperative
Iowa-Illinois Gas and Electric Company
Iowa Power and Light Company
Iowa Public Service Company
Iowa Southern Utilities Company
Lake Superior District Power Company
Minnesota Power & Light Company
Minnkota Power Cooperative, Inc.
Montana-Dakota Utilities Company
Nebraska Public Power District
Northern States Power Company
Northwestern Public Service Company
Omaha Public Power District
United Power Association
United States Bureau of Reclamation

1.0262 Load characteristics. The adjusted net capability for MAPP members from 1976 through 1985 is presented on Figure 1-7. As shown, the 1976 adjusted net capability of MAPP members is projected to be 19,872 MW. By 1985, the adjusted net capability of MAPP members is predicted to increase to 31,878 MW (with OGS). This is because member utilities are planning on adding new generating facilities and other units will be retired. Committed and proposed additions are shown in Table 1-3. Planned retirements are listed in Table 1-4.

1.02621 On the basis of projected sales the total firm capacity obligation of MAPP utilities (as utilities), an increase from 18,849 MW in 1976 to 32,638 MW in 1985 is expected (Figure 1-7).

1.02622 As shown on Figure 1-7, the total (committed) firm obligation of the MAPP members will exceed the adjusted net generating capability in 1978 and after 1982.

1.02623 System deficiency. As shown on Figure 1-7, approximately 1330 MW net new generating capacity must be added to the existing

Table I-3

PROJECTED ADDITIONS OF GENERATING CAPABILITIES OF THE MID-CONTINENT AREA POWER POOL, MEGAWATTS 1976-1985

System	Unit Name		Location		Unit Type	Summer Rating	Committed In-Service Date
NSP	Cornell	4	Cornell	WI	Hydro	1.00	1976
LSDP	White River	1+2	Ashland	WI	Hydro	0.90	1976
IPS	Electrifarm	2	Waterloo	IA	Gas Turb	66.60	1977
ISP	Lansing	4	Lansing	IA	Fossil	260.00	1977
MPL	Milton R. Young	2	Center	ND	Fossil	408.00	1977
NSP	Sherburne Co.	2	Becker	MN	Fossil	680.00	1977
NWPS	Aberdeen Gt.	1	Aberdeen	SD	Gas Turb	22.00	1978
ISU	Burlington Gt.	1	Burlington	IA	Gas Turb	53.00	1978
IPS	Electrifarm	3	Waterloo	IA	Gas Turb	68.80	1978
NPPD	Gentleman	1	Sutherland	NE	Fossil	600.00	1978
BEPC	Clay County	1+2	Gayville	SD	Gas Turb	120.00	1978
CPA	Coal Creek (Share)	1	Underwood	ND	Fossil	254.00	1978
JPA	Coal Creek (Share)	1	Underwood	ND	Fossil	215.00	1978
IPL	Council Bluffs (Shr)	3	Council Bluffs	IA	Fossil	303.00	1979
IPS	Council Bluffs (Shr)	3	Council Bluffs	IA	Fossil	25.00	1979
EILP	Council Bluffs (Shr)	3	Council Bluffs	IA	Fossil	25.00	1979
IIGE	Council Bluffs (Shr)	3	Council Bluffs	IA	Fossil	211.00	1979
IELP	Council Bluffs (Shr)	3	Council Bluffs	IA	Fossil	50.00	1979
OPPD	Nebraska City	1	Nebraska City	NE	Fossil	575.00	1979
DPC	Alma	6	Alma	WI	Fossil	350.00	1979
ISP	Neal (Share)	4	Sioux City	IA	Fossil	100.00	1979
NWPS	Neal (Share)	4	Sioux City	IA	Fossil	50.00	1979
IPS	Neal (Share)	4	Sioux City	IA	Fossil	278.00	1979
UPA	Coal Creek (Share)	2	Underwood	ND	Fossil	215.00	1979
CPA	Coal Creek (Share)	2	Underwood	ND	Fossil	251.00	1979
MPL	Boswell	4	Cohasset	MN	Fossil	500.00	1980
NPPD	Gentleman	2	Sutherland	NE	Fossil	600.00	1980
IPS	Ottumwa (Share)	1	Chillicothe	IA	Fossil	125.00	1980
IPL	Ottumwa (Share)	1	Chillicothe	IA	Fossil	100.00	1980
ISU	Ottumwa (Share)	1	Chillicothe	IA	Fossil	325.00	1980
IIGE	Ottumwa (Share)	1	Chillicothe	IA	Fossil	125.00	1980
MPC	Coyote (Share)	1	Beulah	ND	Fossil	123.00	1981
MDU	Coyote (Share)	1	Beulah	ND	Fossil	82.00	1981
NWPS	Coyote (Share)	1	Beulah	ND	Fossil	41.00	1981
NSP	Sherburne Co.	3	Becker	MN	Fossil	800.00	1981
NPPD	Pumped Hydro	1	Lynch	NE	Hydro	166.67	1982
NPPD	Pumped Hydro	2	Lynch	NE	Hydro	166.67	1982
OPPD	Ft. Calhoun (Share)	2	Ft. Calhoun	NE	Nuclear	575.00	1983
NPPD	Ft. Calhoun (Share)	2	Ft. Calhoun	NE	Nuclear	575.00	1983
NPPD	Pumped Hydro	3	Lynch	NE	Hydro	166.67	1983
NPPD	Pumped Hydro	4	Lynch	NE	Hydro	166.67	1983
NPPD	Pumped Hydro	5	Lynch	NE	Hydro	166.67	1983
NPPD	Pumped Hydro	6	Lynch	NE	Hydro	166.67	1983
NSP	Sherburne Co.	4	Becker	MN	Fossil	800.00	1983
IPL	Central IA. (Share)	1	Central	IA	Nuclear	400.00	1984
MPC	P. R. Young (Share)	2	Center	ND	Fossil	120.00	1984
IIGE	Carroll (Share)	1	Carroll County	IL	Nuclear	165.00	1985
ISP	Carroll (Share)	1	Carroll County	IL	Nuclear	202.00	1985
DPC	Tyrone (Share)	1	Durand	WI	Nuclear	150.00	1985
CPA	Tyrone (Share)	1	Durand	WI	Nuclear	200.00	1985
NSP	Tyrone (Share)	1	Durand	WI	Nuclear	800.00	1985
IELP	1978 Gt.	1		IA	Gas Turb	150.00	1978 Addition
NWPS	Mitchell Gt.	1	Mitchell	SD	Gas Turb	22.00	1980 Addition
BEPC	Laramie River (Shr)	2	Wheatland	WY	Fossil	11.00	1980 Addition
MPL	Coyote (Share)	1	Beulah	ND	Fossil	20.50	1981 Addition
BEPC	Beulah	1	Beulah	ND	Fossil	400.00	1981 Addition
BEPC	Beulah	2	Beulah	ND	Fossil	400.00	1982 Addition
MPL	Brookston	1	Brookston	MN	Fossil	800.00	1984 Addition
IELP	Central IA. (Share)	1	Central	IA	Nuclear	300.00	1984 Addition

Source: Report by Mid-Continent Area Reliability Co-Ordination Agreement (MARCA) to Federal Power Commission, FPC Docket R362, Appendix A-1, April 1, 1976.

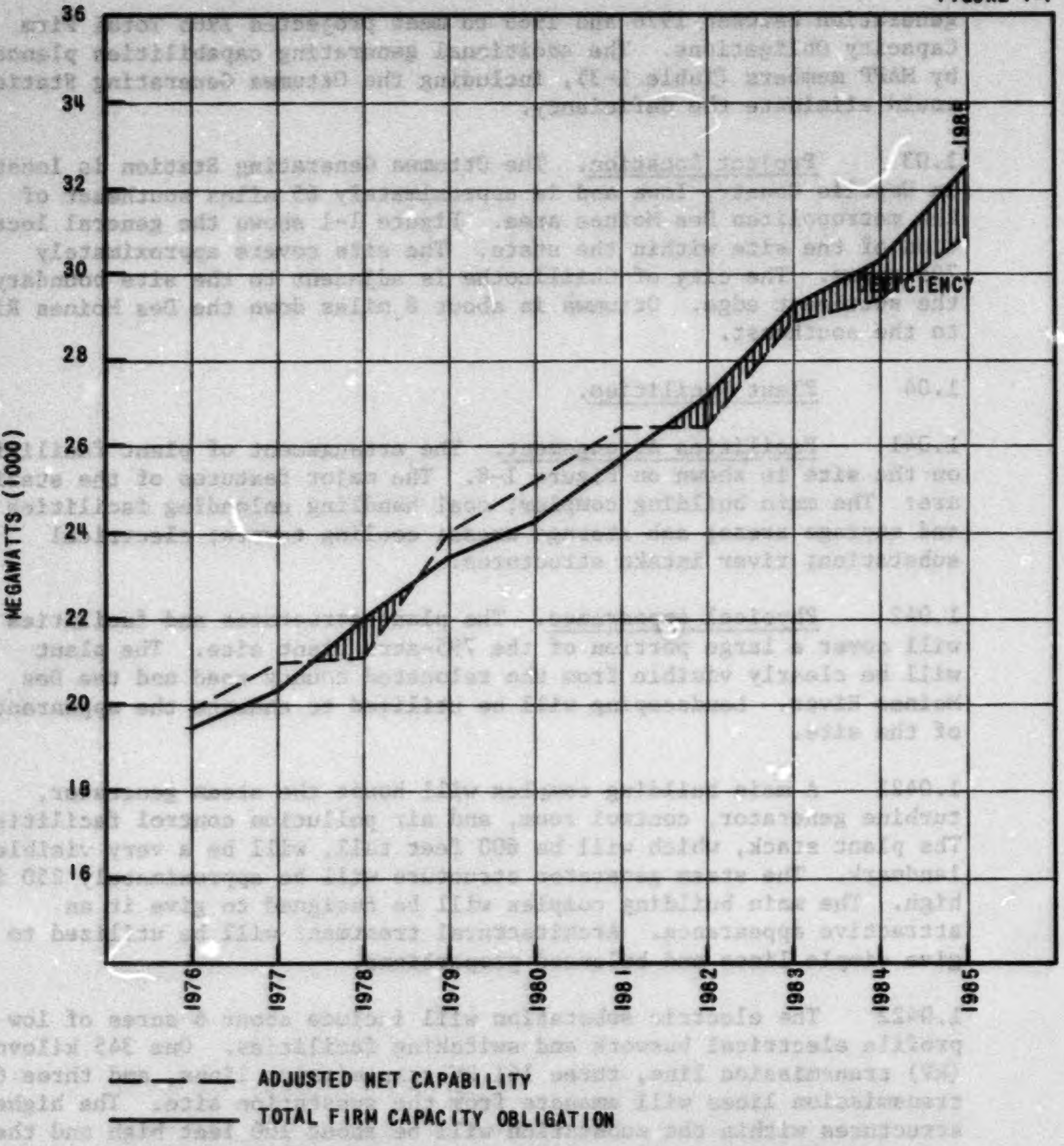
Table 1-4

PROJECTED RETIREMENTS OF GENERATING CAPABILITIES OF THE MID-CONTINENT AREA POWER POOL, MEGAWATTS
1976-1985

System	Unit Name		Location		Unit Type	Summer Rating	Committed In-Service Date	
IPS	Diesel			IA	Diesel	3.00	1976	Retirement
IPS	Maynard	4+5	Waterloo	IA	Fossil	23.20	1976	Retirement
IPS	Diesel			IA	Diesel	6.00	1978	Retirement
IPS	Diesel			IA	Diesel	3.00	1979	Retirement
IPS	Kirk	1+5	Sioux City	IA	Fossil	18.50	1979	Retirement
IPS	Carroll	1+2	Carroll	IA	Fossil	10.61	1981	Retirement
IPS	Diesel			IA	Diesel	2.00	1981	Retirement
IPS	Eagle Grove	1	Eagle Grove	IA	Fossil	9.84	1981	Retirement
IPS	Hawkeye	1+2	Storm Lake	IA	Fossil	22.79	1981	Retirement
NSP	French Island	1+2	Lacrosse	WI	Fossil	28.00	1982	Retirement
NSP	Red Wing	1+2	Red Wing	MN	Fossil	25.00	1982	Retirement
NSP	Various Diesels		Various Locations		Diesel	13.00	1982	Retirement
NSP	Wilmarth	1+2	Mankato	MN	Fossil	25.00	1982	Retirement
NSP	Various Diesels		Various Locations		Diesel	7.00	1983	Retirement
NSP	High Bridge	3+4	St. Paul	MN	Fossil	98.00	1984	Retirement
NSP	Riverside	1+2+6	Minneapolis	MN	Fossil	105.00	1984	Retirement
NWPS	Aberdeen	2	Aberdeen	SD	Fossil	4.50	1976	Retirement
IPS	Dickens	1+2	Dickens	IA	Diesel	2.60	1976	Retirement
IPS	Galbraith	1+2	Galbraith	IA	Diesel	2.60	1976	Retirement
NWPS	Mitchell	2	Mitchell	SD	Fossil	3.90	1976	Retirement
IPS	Sherwood	1+2	Sherwood	IA	Diesel	2.55	1976	Retirement
IIGE	Riverside	1	Bettendorf	IA	Fossil	23.85	1977	Retirement
USBR	Capacity Conversion		To Adverse Water		Hydro	54.00	1977	Derate
IIGE	Moline	M-3	Moline	IL	Fossil	13.52	1977	Retirement
IELP	Sixth Street		Cedar Rapids	IA	Fossil	1.00	1977	Derate
MDU	McBridge	2	McBridge	SD	Fossil	8.50	1977	Retirement
IPS	Dinsdale	1+2	Dinsdale	IA	Diesel	3.00	1977	Retirement
NSP	Lawrence	1-3	Sioux Falls	SD	Fossil	49.00	1977	Retirement
NSP	Black Dog	1-4	Minneapolis	MN	Fossil	62.00	1978	Derate
USBR	Capacity Conversion		To Adverse Water		Hydro	47.00	1978	Derate
NSP	Granite City	2+4	St. Cloud	MN	Gas Turb	2.00	1978	Derate
NSP	High Bridge	3-6	St. Paul	MN	Fossil	31.00	1978	Derate
NSP	Key City	2+4	Mankato	MN	Gas Turb	2.00	1978	Derate
NSP	Minnesota Valley	3	Granite Falls	MN	Fossil	1.00	1978	Derate
NSP	Red Wing	1+2	Red Wing	MN	Fossil	3.00	1978	Derate
NSP	Riverside	1+2+6	Minneapolis	MN	Fossil	45.00	1978	Derate
IELP	Sixth Street		Cedar Rapids	IA	Fossil	0.50	1978	Derate
NSP	West Faribault	3	Faribault	MN	Gas Turb	1.00	1978	Derate
NSP	Wilmarth	1+2	Mankato	MN	Fossil	3.00	1978	Derate
NWPS	Aberdeen	3	Aberdeen	SD	Fossil	7.80	1978	Retirement
NWPS	Mitchell	3	Mitchell	SD	Fossil	8.50	1978	Retirement
USBR	Capacity Conversion		To Adverse Water		Hydro	20.00	1979	Derate
IELP	Sixth Street		Cedar Rapids	IA	Fossil	0.50	1979	Derate
NPPD	K Street	3	Lincoln	NE	Fossil	18.00	1979	Retirement
USBR	Capacity Conversion		To Adverse Water		Hydro	20.00	1980	Derate
IELP	Sixth Street		Cedar Rapids	IA	Fossil	0.50	1980	Derate
BEPC	William J. Neal		Voltaire	ND	Fossil	35.00	1980	Retirement
USBR	Capacity Conversion		To Adverse Water		Hydro	10.00	1981	Derate
IELP	Sixth Street		Cedar Rapids	IA	Fossil	0.50	1981	Derate
IELP	Sixth Street		Cedar Rapids	IA	Fossil	0.50	1982	Derate
IELP	Sixth Street		Cedar Rapids	IA	Fossil	0.50	1983	Derate
MPC	Warroad	1+2+5	Warroad	MN	Diesel	2.30	1983	Retirement
IELP	Sixth Street		Cedar Rapids	IA	Fossil	0.50	1984	Derate
MPL	Milton R. Young	2	Center	ND	Fossil	120.00	1984	Derate
IELP	Sixth Street		Cedar Rapids	IA	Fossil	0.50	1985	Derate

Source: Report by Mid-Continent Area Reliability Co-Ordination Agreement (MARCA) to Federal Power Commission, FPC Docket R362, Appendix A-1, April 1, 1976.

FIGURE I-7



SOURCE: REPORT, MID-CONTINENT AREA RELIABILITY CO-ORDINATION AGREEMENT (MARCA) TO THE FEDERAL POWER COMMISSION PURSUANT TO FPC DOCKET R-362, APPENDIX A-1, APRIL 1, 1975

PROJECTED TOTAL FIRM CAPACITY OBLIGATION AND ADJUSTED NET CAPABILITY OF MID-CONTINENT AREA POWER POOL MEMBERS generation between 1976 and 1985 to meet projected 1985 Total Firm Capacity Obligations. The additional generating capabilities planned by MAPP members (Table 1-3), including the Ottumwa Generating Station, would eliminate the deficiency.

1.03 Project Location. The Ottumwa Generating Station is located in Wapello County, Iowa and is approximately 65 miles southeast of the metropolitan Des Moines area. Figure 1-1 shows the general location of the site within the state. The site covers approximately 795 acres. The city of Chillicothe is adjacent to the site boundary on the southeast edge. Ottumwa is about 8 miles down the Des Moines River to the southeast.

1.04 Plant Facilities.

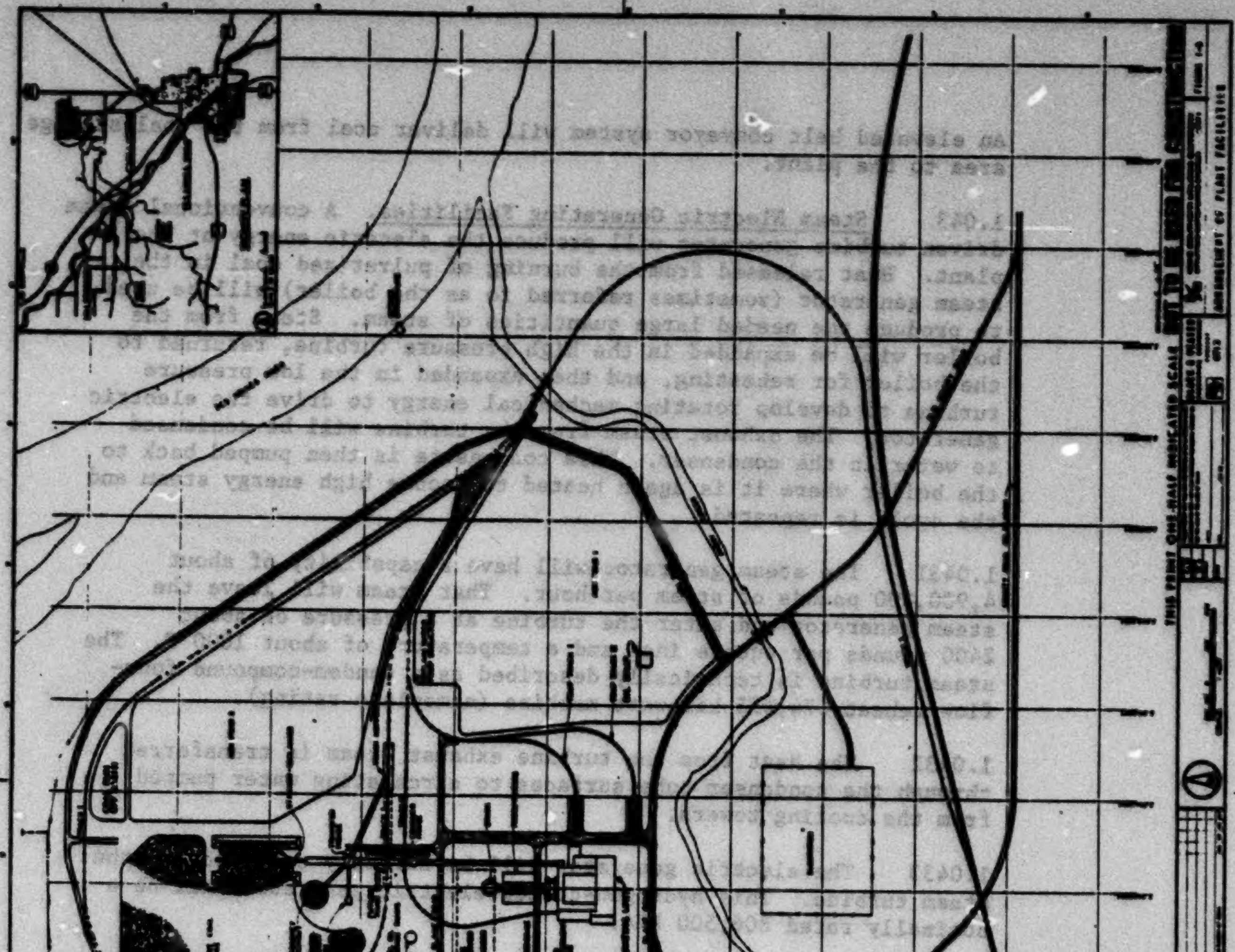
1.041 Facilities Arrangement. The arrangement of plant facilities on the site is shown on Figure 1-8. The major features of the station are: The main building complex; coal handling unloading facilities and storage areas; ash storage areas; cooling towers; electrical substation; river intake structures.

1.042 Physical Appearance. The plant structures and facilities will cover a large portion of the 795-acre plant site. The plant will be clearly visible from the relocated county road and the Des Moines River. Landscaping will be utilized to enhance the appearance of the site.

1.0421 A main building complex will house the steam generator, turbine generator, control room, and air pollution control facilities. The plant stack, which will be 600 feet tall, will be a very visible landmark. The steam generator structure will be approximately 250 feet high. The main building complex will be designed to give it an attractive appearance. Architectural treatment will be utilized to give simple lines and balanced proportions.

1.0422 The electric substation will include about 6 acres of low profile electrical buswork and switching facilities. One 345 kilovolt (kV) transmission line, three 161 kV transmission lines, and three 69 kV transmission lines will emanate from the substation site. The highest structures within the substation will be about 100 feet high and the highest transmission line structures will be about 125 feet high.

1.0423 The area east and northeast of the main building complex will be used for the ash storage containments. These containments will be earthen embankments with gradual slopes. Maximum embankment height will be approximately 30 feet above grade. The coal storage area will utilize the area north of the main building complex. Coal in the inactive storage area will be compacted and stored to a 40-foot depth.


THIS PRINT ONE-HALF INDICATED SCALE
ARRANGEMENT OF PLANT FACILITIES

An elevated belt conveyor system will deliver coal from the coal storage area to the plant.

1.043 **Steam Electric Generating Facilities**. A conventional steam driven turbine generator will produce the electric energy at the plant. Heat released from the burning of pulverized coal in the steam generator (sometimes referred to as the boiler) will be used to produce the needed large quantities of steam. Steam from the boiler will be expanded in the high pressure turbine, returned to the boiler for reheating, and then expanded in the low pressure turbine to develop rotating mechanical energy to drive the electric generator. The exhaust steam from the turbine will be condensed to water in the condenser. This condensate is then pumped back to the boiler where it is again heated to become high energy steam and the cycle is repeated.

1.0431 The steam generator will have a capability of about 4,900,000 pounds of steam per hour. That steam will leave the steam generator and enter the turbine at a pressure of about 2400 pounds per square inch and a temperature of about 1000 F. The steam turbine is technically described as a tandem-compound four-flow reheat 674,453 kilowatt machine (nameplate rating).

1.0432 The heat from the turbine exhaust steam is transferred through the condenser tube surfaces to circulating water pumped from the cooling towers.

1.0433 The electric generator will be directly connected to the steam turbine. This hydrogen-cooled electric generator will be a nominally rated 806,500 kVA.

1.044 **Plant Water Use**. Water will be required for a variety of uses at the Ottumwa Generating Station. These uses are summarized in Table 1-5, and a schematic diagram for the station water uses is given on Figure 1-9. The maximum station water usage was based on the unit operating at 100 per cent load, and the average usage was based on 70 per cent load. Both cases assumed yearly average meteorological conditions and an average Des Moines River water quality.

1.0441 Makeup water for the station will come from the Des Moines River. The rate of water withdrawal from the Des Moines is estimated to be 11,091,000 gallons per day (approximately 17 cfs) for the maximum operating condition, and 7,802,000 gallons per day (approximately 12 cfs) for the average operating condition. The river water will be drawn through traveling screens at the intake structure and pumped to the water pretreatment system.

TABLE 1-5

WATER MASS BALANCE
FLOW TABULATIONS*

Stream No.	Description	Maximum Conditions 100% Load Factor (x 10^3 gpd)	Average Conditions 70% Load Factor (x 10^3 gpd)
1	Total River Water Makeup	11,127	7,834
2	Basin Makeup	0	0
3	Water Pretreatment System Makeup	11,127	7,834
4	Gravity Filter Makeup	383	309
5	Gravity Filter Backwash Wastes	3	3
6	Solids Contact Basin Blowdown	130	92
7	Water Pretreatment Sump Effluent	133	95
8	Circulating Water Makeup	10,614	7,433
9	Cooling Tower Evaporation & Drift	10,028	7,026
10	Total Circulating Water Blowdown	694	479
11	Circulating Water Pumps Bearing Water	108	72
12	Ash Sluicing Surge Tank Makeup††	0	0
13	Potable Water for Miscellaneous Plant Uses	36	36
14	Miscellaneous Wastes to Plant Drains	33	33
15	Miscellaneous Plant Drains Discharge	59	53
16	Sanitary Facilities Wastes	3	3
17	Sewage Treatment Plant Effluent	3	3
18	Makeup to Sodium Softeners	164	126
19	Wastes from Sodium Softeners	3	3
20	Makeup to Flash Evaporator	161	123
21	Flash Evaporator Blowdown	23	17
22	Makeup to Steam Cycle	138	106
23	Condensate Polishers Regeneration Wastes	5	5
24	Chemical Cleaning Wastes†	0	0
25	Condensate to Condensate Polishers	7,160	5,015
26	Polished Condensate Returned to Condenser	7,155	5,010
27	Soot Blowing and Miscellaneous Steam Losses	80	64
28	Steam Generator Blowdown	53	37
29	Rainfall Runoff From Roof & Yard Drains	167	167
30	Makeup to Ash Sluicing Surge Tank	2,696	1,894
31	Makeup to Bottom Ash System	3,390	2,373
32	Evaporation from Bottom Ash System	288	202
33	Ash Water Returned to Bottom Ash Basin	3,174	2,243
34	Hopper Seal Water	72	72
35	Ash Water Pit Effluent	53	37
36	Fly Ash Basin Makeup	0	0
37	Coal Pile Runoff Basin Discharge to River	53	53
38	Rainfall on Fly Ash Basin	92	92
39	Evaporation from Fly Ash Basin	92	92
40	Rainfall on Bottom Ash Basin	101	101
41	Evaporation from Bottom Ash Basin	110	110
42	Final Discharge to Des Moines River	889	700
43	Bottom Ash Basin Makeup**	0	0

TABLE 1-5 (CONT'D)

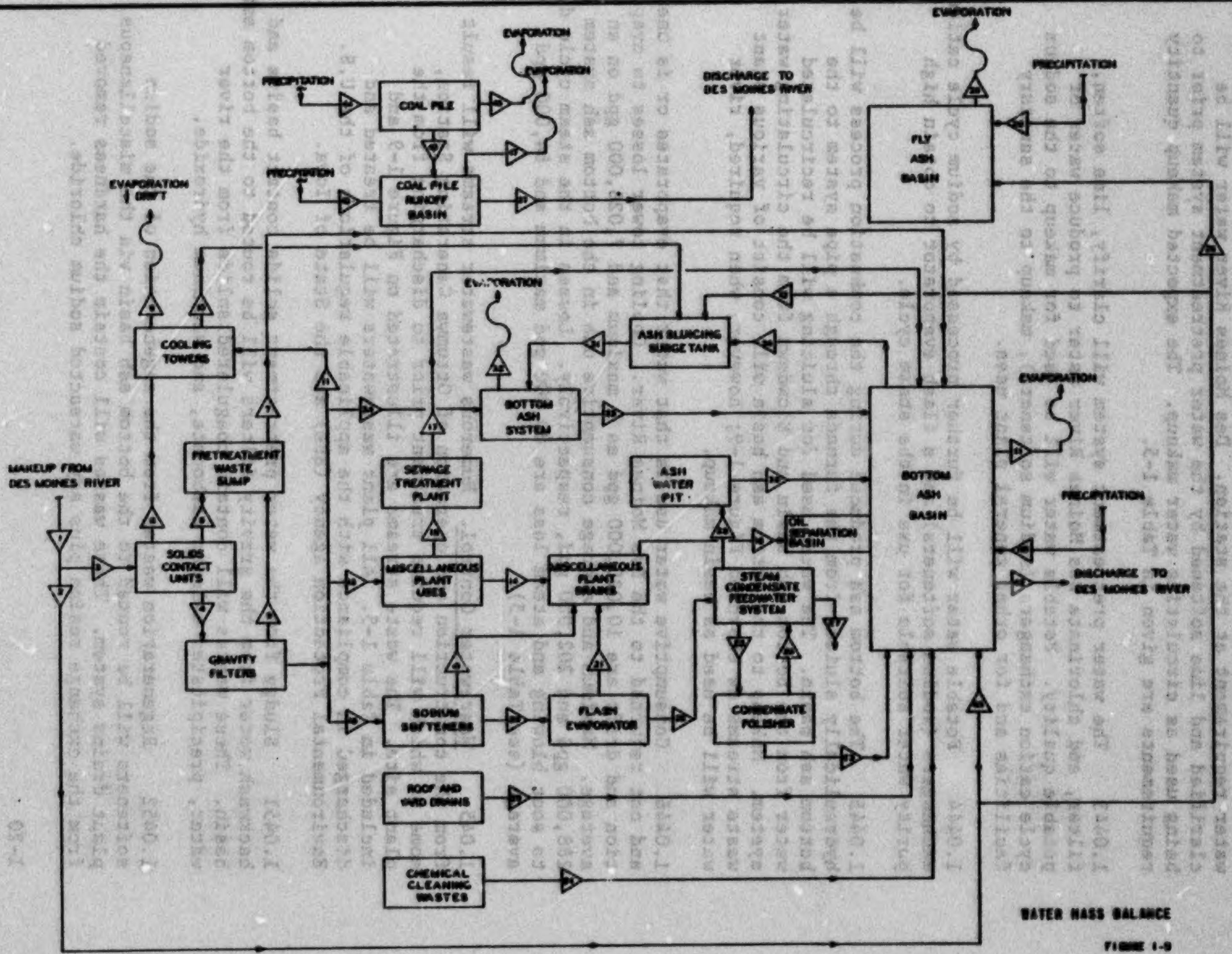
Stream No.	Description	Maximum Conditions 100% Load Factor (x 10^3 gpd)	Average Conditions 70% Load Factor (x 10^3 gpd)
44	Rainfall on Coal Pile	92	92
45	Coal Pile Runoff	51	51
46	Evaporation from Coal Pile	41	41
47	Evaporation from Coal Pile Runoff Basin	6	6
48	Rainfall on Coal Pile Runoff Basin	8	8

* The flows stated are based on yearly averages, and as such may not be the expected normal or maximum flows and should not be used for equipment design.

** This stream will be zero flow except in the case where makeup to the bottom ash basin is required.

† Chemical cleaning will occur prior to initial operation and then every two to five years afterwards.

†† Provisions for routing river water to the ash sluicing surge tank during plant start-up will be provided.



WATER MASS BALANCE

FIGURE I-9

1.0442 The makeup to the circulating water system will be the largest water requirement at the station. Des Moines River water will be clarified and lime softened by the water pretreatment system prior to being used as circulating water makeup. The expected makeup quantity requirements are given in Table 1-5.

1.0443 The water pretreatment system will clarify, lime soften, filter, and chlorinate Des Moines River water to produce water of potable quality. Potable water will be used for makeup to the sodium cycle cation exchangers (sodium softeners), makeup to the sanitary facilities and for other general plant uses.

1.0444 Potable water will be further processed by sodium cycle cation exchangers (sodium softeners) and a flash evaporator to obtain high purity water suitable for use in the steam cycle.

1.0445 The bottom ash produced during the combustion process will be hydraulically sluiced from the furnace through a pipe system to the bottom ash basin. The water used for sluicing will be recirculated water from the bottom ash basin and blowdown from the circulating water system. Makeup to the bottom ash basin will consist of various plant waste streams as shown on Figure 1-9; however, when required, river water will be used as basin makeup.

1.0446 Consumptive water use is that water that evaporates or is used and not returned to the Des Moines River. Cooling tower losses to evaporation and drift are 10,028,000 gpd as a maximum and 7,026,000 gpd on an average. Maximum and average consumptive use in the bottom ash system is 288,000 gpd and 202,000 gpd, respectively. Losses in the steam cycle due to soot blowing and steam loss are 80,000 gpd maximum and 64,000 gpd average (see Table 1-5).

1.045 Wastewater Control. Numerous wastewater streams will result from the construction and operation of Ottumwa Generating Station, some of which will require treatment prior to discharging from the plant site. The waste streams are illustrated on Figure 1-9 and included in Table 1-5. All plant wastewaters will be treated and discharged in compliance with the applicable regulations of the U.S. Environmental Protection Agency (EPA) and the State of Iowa.

1.0451 Sludge from the water pretreatment solids contact basins and backwash water from the gravity filters will be routed to the bottom ash basin. These wastes will contain coagulated solids from the river water, precipitated calcium carbonate, and aluminum hydroxide.

1.0452 Regeneration wastes from the regeneration of the sodium softeners will be routed to the bottom ash basin via the miscellaneous plant drains system. These wastes will contain the hardness removed from the exchange resins plus any unreacted sodium chloride.

1.0453 The blowdown from the flash evaporator will have a high dissolved solids content and will be routed to the bottom ash basin, again via the miscellaneous plant drains system.

1.0454 Condensate polisher wastes will be routed to the bottom ash basin. These wastes will consist of solid filter media.

1.0455 Continuous removal of water (blowdown) is required for control of dissolved solids in the circulating water system. The blowdown will be discharged to the ash sluicing surge tank and used for bottom ash sluicing, prior to being discharged to the bottom ash basin. The blowdown will consist of pretreated river water concentrated approximately 15 times.

1.0456 The sanitary facilities wastes will be routed to a sewage treatment plant located on the Ottumwa site. The discharge from the sewage treatment plant will meet all regulatory discharge requirements and will be routed to the bottom ash basin.

1.0457 Miscellaneous plant drains include floor drains and various waste lines located throughout the station. These wastes are collected, routed through an oil-water separating basin and discharged to the bottom ash basin.

1.0458 The blowdown from the boiler will be routed to the bottom ash basin via the ash water pit.

1.0459 Bottom ash will be sluiced to the bottom ash basin by a hydraulic sluicing system utilizing blowdown from the circulating water system and recirculated water from the bottom ash basin. The bottom ash sluicing system waste streams will contain a high concentration of suspended solids which will settle out in the bottom ash basin.

1.04510 The fly ash will be handled dry and will be deposited under water in the fly ash basin for storage. The surface area of the fly ash basin will be approximately 34 acres.

1.04511 Rainfall runoff from the coal storage area will be to a runoff basin with a surface area of about 2.2 acres. This basin will be designed to contain the runoff from two consecutive 10-year, 24-hour rainfall events. Discharge will be to the Des Moines River by a submerged siphon.

1.04512 The wastes resulting from preoperational chemical cleaning will be discharged to the bottom ash basin. This basin will allow the cleaning wastes to neutralize and suspended solids to settle prior to discharging from the plant site.

1.04513 The bottom ash basin will serve as a collection point for all plant waste streams and the plant yard and roof drains. The 40.5 acre basin will provide sufficient retention of wastewater to allow settling of suspended solids and equalization of pH. In this manner all non-consumptive wastewater from the station will be monitored and discharged to the Des Moines River from a single discharge point. This discharge will meet all the discharge requirements of the EPA and State of Iowa.

1.046 Sanitary Waste Disposal. A sewage treatment plant will treat the sewage produced during the operation of Ottumwa Generating Station. The treatment plant will serve approximately 60 employees along with any visitors or extra maintenance personnel at the plant site. During the construction phase, portable, self-contained sanitary facilities will be used to meet the additional sewage load. The sewage treatment plant will be a packaged, activated sludge unit of the extended aeration process type. The unit will include screening equipment, not less than 24-hour aeration tank, 4-hour clarification compartment, and sludge return and skimming facilities. The treatment plant will provide a sewage treatment capacity of approximately 10,000 gallons per day. A 90 per cent or greater BOD_5 (5-day biochemical oxygen demand) and suspended solids reduction will be achieved by the sewage treatment plant.

1.0461 The treated sewage will be discharged to the bottom ash basin where further reduction of suspended solids and BOD_5 will occur prior to discharging to the Des Moines River.

1.047 Circulating Water System. The circulating water system will provide cooling water to a surface condenser where exhaust steam from the turbine is condensed to water by transferring the residual heat energy to the circulating water. The circulating water passes through mechanical draft cooling towers where the residual heat is released to the atmosphere through evaporation and, to a lesser degree, by conduction. The circulating water system operates as a closed system by continuous recirculation of water between the condenser and the cooling towers. Because a portion of the circulating water is evaporated, makeup water is required. In addition, some water is also required to replace water which will be continuously removed from the cycle to maintain an acceptable dissolved solids concentration--so-called cooling tower "blowdown."

1.0471 The circulating water system will also provide cooling water to auxiliary cooling water systems.

1.0472 Makeup water for the circulating water system will be taken from the water pretreatment system. Water released from the circulating water system will be used in other plant systems, such as the ash disposal system, prior to storage and eventual release to the Des Moines River.

1.0473 Maximum circulating water system flow is estimated to be approximately 278,000 gallons per minute (gpm). Condenser requirements are approximately 248,000 gpm and auxiliary cooling water requirements are approximately 30,000 gpm. Makeup to the circulating water system may reach a short-term maximum of approximately 7500 gpm.

1.048 Fuel Supply, Transportation, and Utilization. Coal will be supplied from mines in the Powder River Basin in Wyoming. The coal is subbituminous, characterized as low sulfur content with a heating value of about 8000 Btu per pound. A contract has not been signed with a specific coal supplier; however, an analysis of the worst case Powder River Basin coal being considered for use at OGS is shown in Table 1-6.

1.0481 Specially designed unit trains will deliver coal to the plant site. Each train will have a capacity in excess of 10,000 tons. The 675,000 kilowatt unit will consume from 1.9 to 2.7 million tons of coal annually, depending on annual load factor. Approximately 175 to 250 trains a year or 3 to 5 per week, will be required to provide that amount of fuel.

1.0482 The coal cars will be unloaded and the coal will be delivered to either active or inactive storage or the plant silos. The active coal storage area will provide a supply of fuel for about 4 days operation. Inactive storage is required to provide a reserve supply of fuel on the plant site. Careful compaction of the inactive stored coal will be necessary to prevent spontaneous combustion. About 90 days supply of coal will be stored in the inactive storage area. Typical trace element concentrations of the coal and expected emissions from Ottumwa Generating Station are shown in Table 1-7.

1.0483 The coal stored in the active storage will be supplemented as new shipments of coal arrive. Similarly, coal will be reclaimed from active storage or directly from the railroad cars and transported with the elevated conveyor system to the coal silos adjacent to the steam generator. The coal must be crushed to a size about 2 inches or smaller before it is delivered to the silos. The coal then will be pulverized and burned in the boiler.

1.0484 A discussion concerning the selection of western coal for use at OGS and the alternate fuels considered is given in Section 6.04. Alternate modes of fuel transportation are discussed in Section 6.06.

1.049 Combustion Gases and Air Quality Control

1.0491 Introduction. The combustion of coal in the boiler furnace yields a large volume of gaseous and solid byproducts. Certain

TABLE 1-6

ANALYSIS OF POWDER RIVER BASIN WESTERN COAL[a]

Proximate Analysis	Average	Range
As Received		
Moisture	31.5%	29.2 - 33.6%
Ash	5.7%	4.6 - 8.5%
Volatile Matter	31.3%	28.9 - 34.1%
Fixed Carbon	31.5%	28.0 - 33.7%
Sulphur	0.46%	0.24 - 0.83%
Btu	8055 Btu/lb	7776 - 8313 Btu/lb
Sulphur Forms		
Pyritic	0.35%	0.250 - 0.450%
Sulphate	0.009%	0.009%
Organic	0.399%	0.293 - 0.504%
Water Soluble Alkalines		
Na_2O	0.64%	0.094 - 0.10%
K_2O	0.005%	Nil - 0.009%
Mineral Content of Ash **Oxide**		
SiO_2	22.9%	5.9 - 40.3%
Al_2O_3	15.6%	9.4 - 19.4%
CaO	36.9%	22.8 - 51.2%
Fe_2O_3	5.0%	3.5 - 9.1%
K_2O	0.2%	0.1 - 0.8%
Na_2O	1.3%	0.4 - 1.8%
TiO_2	4.9%	0.2 - 12.3%
P_2O_5	1.4%	0.6 - 2.2%
Grindability		
	57.5%	48.0 - 71.0%
Equilibrium Moisture		
	27.7%	

TABLE 1-6 (CONT'D)

Ultimate Analysis	**Average**	**Range**
H_2O	31.5%	29.16 - 33.85%
Ash	5.7%	4.59 - 9.57%
S	0.46%	0.24 - 0.83%
N	0.70%	0.66 - 0.79%
Cl	0.01%	0.01 - 0.02%
C	46.28%	43.67 - 47.7%
H	6.81%	6.21 - 7.20%
O	39.62%	25.70 - 41.78%
Fusion Temperature of Ash		
Initial (ID)	2152°F	2120 - 2210°F
Softening (H-D)	2195°F	2120 - 2282°F
Hemispherical (H=1/2 W)	2254°F	1153 - 2372°F
Fluid Temperature (FT)	2298°F	1220 - 2399°F

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[a] This analysis is of the worst case coal being considered for use at OGS. The coal finally contracted for will be this quality of better.

TABLE 1-7

ANALYSIS OF TRACE ELEMENTS OF POWDER BASIN COAL AND EXPECTED EMISSIONS FROM OTTUMWA GENERATING STATION

Element	Concentration In Coal	Feed Rate	Per Cent Emitted	Emission Rate	Emission Rate	Emission Rate
	ppm	lb/hr*	%	ppm*	gm/sec*	lb/hr*
Arsenic	0.4 - 2.3	0.35 - 2.0	100	0.044 - 0.25	0.044 - 0.25	0.35 - 2.0
Barium	41 - 202	35.7 - 176	0.48		0.025 - 0.11	0.17 - 0.84
Beryllium	0.03 - 0.92	0.03 - 0.8	0.48		0.000015 - 0.0005	0.00012 - 0.0038
Boron	12 - 73	1.04 - 63.5	0.48		0.0063 - 0.038	0.05 - 0.31
Cadmium	0.16 - 1.83	0.14 - 1.6	0.48		0.00009 - 0.00095	0.0007 - 0.0076
Chromium	0.8 - 14.1	0.69 - 12.2	0.48		0.0004 - 0.0074	0.0033 - 0.059
Copper	3.8 - 18.4	3.3 - 16.4	0.48		0.002 - 0.010	0.016 - 0.078
Cyanide	0.1	0.082	0.48		0.00005	0.00042
Fluoride	80 - 350	69.6 - 304	0.48		0.042 - 0.18	0.33 - 1.46
Gallium	0.03 - 0.92	0.03 - 0.8	0.48		0.000015 - 0.0005	0.00012 - 0.0038
Iron	837 - 2,980	728 - 2,591	0.48		0.44 - 1.57	3.49 - 12.44
Lead	0.2 - 3.1	0.174 - 2.7	0.48		0.0001 - 0.0016	0.0008 - 0.013
Mercury	0.001 - 0.03	0.00087 - 0.026	9 - 70	0.00001 - 0.0022	0.00001 - 0.0023	0.000078 - 0.018
Nickel	0.2 - 6.0	0.174 - 5.2	0.48		0.0001 - 0.0031	0.0008 - 0.025
Selenium	0.01 - 0.21	0.0087 - 0.183	100	0.001 - 0.023	0.0011 - 0.023	0.0087 - 0.18
Thorium	0.97 - 472	0.84 - 410	0.48		0.0005 - 0.25	0.004 - 1.97
Uranium	0.6 - 3.0	0.52 - 2.6	0.48		0.0003 - 0.0016	0.0025 - 0.013
Vanadium	10 - 71	8.7 - 61.8	0.48		0.0053 - 0.037	0.042 - 0.29
Zinc	4.4 - 31.4	3.8 - 27.3	0.48		0.0023 - 0.017	0.018 - 0.13

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*Based on a Coal Feed Rate of 874,065 lb/hr.

constituents of combustion byproduct gases are designated air pollutants. The discharge to the atmosphere of these air pollutants is subject to specific regulatory limitations. Various measures will be utilized to control the emission of air pollutants to ensure that emission rates and resulting ground level pollutant concentrations are within regulatory limits.

1.04911 Calculations show that 1,900,000 scfm (at 77 F and 29.92 inches of mercury) of gaseous wastes will result from operation of the boiler at maximum capability. These gases will generally include the constituents shown in Table 1-8. The amounts of the constituents present depend upon the particular fuel burned and specific operating conditions. Among the constituents, particulate matter as well as the oxides of sulfur and oxides of nitrogen are designated air pollutants and their discharge to the atmosphere is subject to limitations established by federal and Iowa regulatory authorities. Carbon monoxide and unburned hydrocarbons also are regulated and they will be emitted from the generating station. Their concentrations will be so low, however, that they will have an insignificant effect on air quality.

Table 1-8

COMBUSTION GAS CONSTITUENTS

Nitrogen
Carbon Dioxide
Water Vapor
Oxygen
Sulfur Dioxide
Nitrogen Dioxide
Carbon Monoxide
Unburned Hydrocarbons
Particulate Matter

1.0492 Air pollution control system. Emissions of nitrogen oxides, sulfur oxides, and particulate matter are limited by equipment design, fuel selection, and the use of control equipment. Atmospheric discharges from a tall stack will limit ground level concentrations. A detailed discussion of expected ambient air concentrations is given in Section 4.02. The following measures described will achieve the degree of air pollutant discharge control required by regulatory standards.

1.04921 Nitrogen oxide control. The control of nitrogen oxide emissions will be achieved by furnace design. Steam generator specifications obligate the manufacturer to guarantee nitrogen oxide emission rates below the level specified by regulatory standards.

Control of the combustion process in the furnace is the best known method for limiting nitrogen oxide emissions.

1.04922 Sulfur oxide control. Sulfur oxide emissions will be minimized by fuel selection. Low sulfur, subbituminous western coal has been selected as the plant fuel supply. The coal supply contract will specify the maximum acceptable sulfur content at a level low enough to assure compliance with all applicable sulfur dioxide emission standards. Space has been allotted for the installation of sulfur oxide removal equipment should low sulfur coal not be available at some future date.

1.04923 Particulate matter control. Particulate matter emissions will be controlled by the use of an electrostatic precipitator. This precipitator will be designed and guaranteed to remove not less than 99.4 per cent of the particulate matter from the combustion gas stream or produce a dust loading at the outlet of the precipitator of not more than 0.0005 grains per acfm, whichever is least stringent. The efficiency has been specified at this level so as to meet all applicable particulate matter emission standards including regulations applicable to visible emissions.

a. The precipitator will be designed to achieve sustained design efficiency over its lifetime. The precipitator, hoppers, inlet and outlet plenums, and ductwork will be heavily insulated to minimize heat loss and corrosion. The rapping system will be designed and field adjusted so that rapping impulses are delivered to both the emitting and collecting electrodes as required for sustained high efficiency operation without dust re-entrainment.

b. The combustion gases will be discharged to the atmosphere from a tall plant stack after leaving the electrostatic precipitator. The stack will be 600 feet in height and will provide good dispersion of the gases.

1.04924 Trace Elements. The expected emission concentrations of trace element are as shown in Table 1-7. A discussion of expected ambient air concentrations is given in Section IV, page 4-18.

1.0493 Ash Handling And Storage System. Ash will be produced at a rate of about 28 tons per hour when the steam generator is operating at maximum capability and firing the typical coal that is representative of the fuels that will be burned. This ash will consist of about 90 per cent fly ash and about 10 per cent bottom ash.

1.04931 The fly ash will be entrained in the flue gas and collected in the electrostatic precipitator. The bottom ash, consisting of ash particles heavier than fly ash, will remain in the steam generator furnace and be collected in hoppers located below the furnace area.

1.04932 All ash will be stored in the ash disposal areas located east of the main generating complex as shown on Figure 1-7. Adjacent, but separate, storage areas will be provided for bottom ash and fly ash. The earthen embankments that form the storage containments will be of sufficient height to prevent the entrance of flood waters.

1.04933 The bottom ash collected in the furnace bottom hoppers will be sluiced through a piping system to the bottom ash disposal area by means of hydraulic ejectors. After the bottom ash settles in the disposal area, the sluice water will be recycled for bottom ash sluicing.

1.04934 Moistened fly ash from western subbituminous coal will harden to form a solid material. For this reason, fly ash will be handled in a dry state. The fly ash collected in the precipitator will be transported by pneumatic transport system to fly ash storage silos. Fly ash will be trucked from the silos to the fly ash pond. The fly ash is pneumatically unloaded at the fly ash pond under water. Off-site storage of fly ash will probably be necessary in the latter years of Unit 1 operation.

1.04935 Fly ash may have commercial value in the manufacture of cement or as an additive for concrete. If a market for the fly ash ever develops, the fly ash will be trucked from the storage silos to the point of use. The capacity of the fly ash disposal area could possibly be reduced if a substantial amount of fly ash could be marketed.

1.0494 Transmission Facilities. Three 161 kV circuits, and one 345 kV circuit will probably be required to transmit power from the Ottumwa Generating Station.

II ENVIRONMENTAL SETTING WITHOUT THE PROJECT

2.01 Geology

2.011 Introduction. This section is a summary of the regional and site geology present at Iowa Southern Utilities Ottumwa Generating Station based on available literature and field investigations represented by on-site borings. Regional Geology includes a discussion of the physiography, stratigraphy, and structural features present in southeastern Iowa. Estimates of predicted earthquake intensity (Modified Mercalli) for the site are presented in Seismology. The Site Geology subsection summarizes the characteristics of surficial deposits and consolidated bedrock beneath the site area.

2.012 Regional Geology

2.0121 Physiography. The Ottumwa Generating Station site, is located primarily north of Middle Avery Creek on an erosional terrace southwest of the flood plain of the Des Moines River in Wapello County. The county lies in the Dissected Till Plains of the Central Lowlands physiographic province. This subprovince exhibits a greater degree of dissection and a general absence of end moraines, lakes, or lake plains in comparison to the other glaciated parts of the Central Lowlands. The topographic relief was developed by a post-glacial, well-integrated drainage system upon the nearly level Kansan age till plain.

2.01211 The till plain has a gentle slope to the southeast which is paralleled by the flow of the major streams.

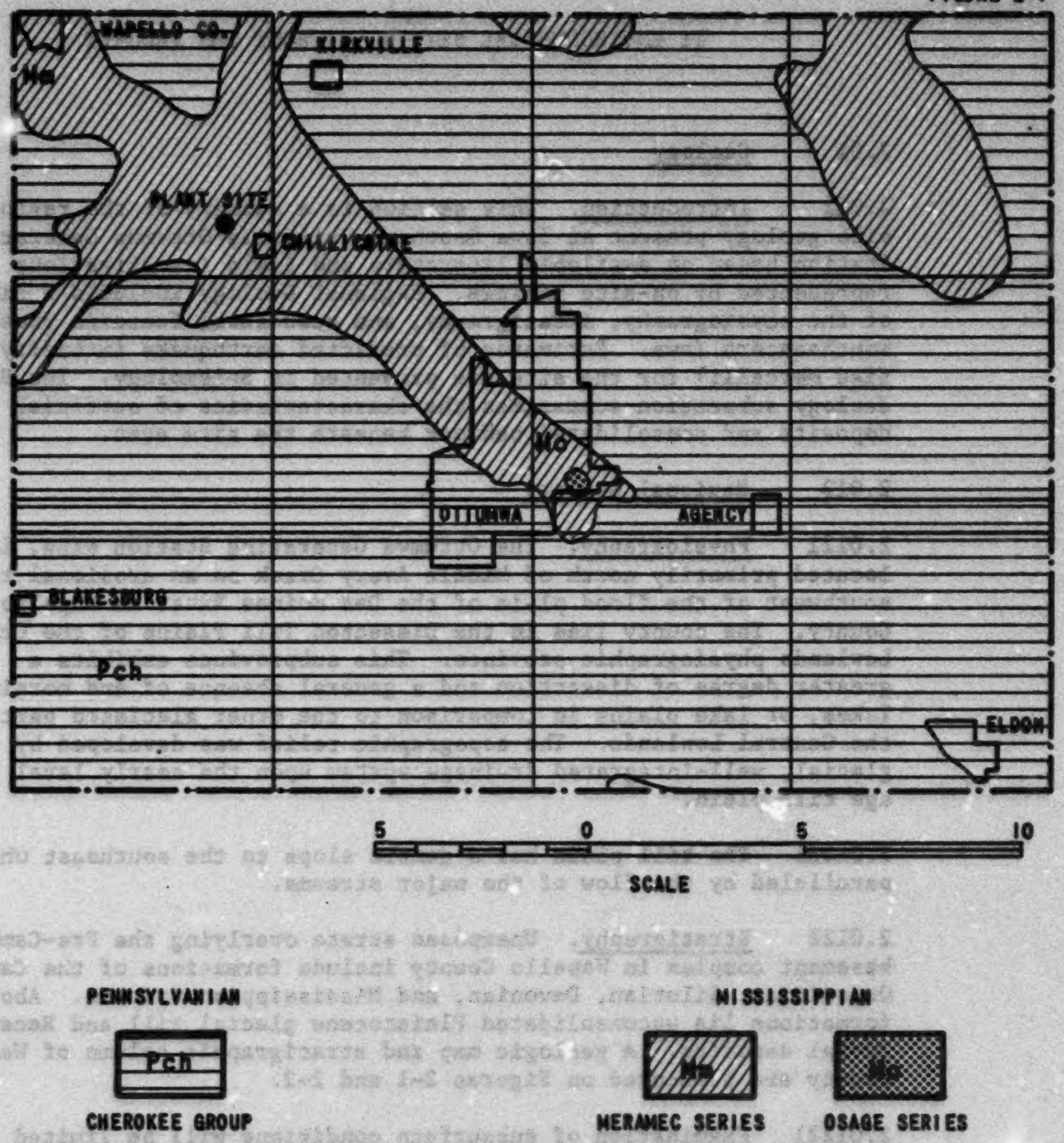
2.0122 Stratigraphy. Unexposed strata overlying the Pre-Cambrian basement complex in Wapello County include formations of the Cambrian, Ordovician, Silurian, Devonian, and Mississippian Systems. Above these formations lie unconsolidated Pleistocene glacial till and Recent alluvial deposits. A geologic map and stratigraphic column of Wapello County are presented on Figures 2-1 and 2-2.

2.01221 Examination of subsurface conditions will be limited to those formations exposed at the surface in the county.

2.0123 Paleozoic era. Two Paleozoic systems are represented at the surface in Wapello County, the Mississippian and the Pennsylvanian.

2.01231 Mississippian age rocks are believed to have been deposited in warm shallow seas which fluctuated somewhat in geographic extent. The oldest rocks exposed in the county belong to the Osage Series, the

FIGURE 2-1



SOURCE: IOWA GEOLOGICAL SURVEY MISCELLANEOUS MAP SERIES 4, 1973.

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BEDROCK GEOLOGY OF WAPELLO COUNTY

FIGURE 2-2

PENNSYLVANIAN SYSTEM	DES MOINESIAN SERIES	CHEROKEE GROUP	CYCLIC DEPOSITS WITH CARBONACEOUS SHALE, CLAY, SILTSTONE, SANDSTONE THICK COAL BEDS AND MINOR, BUT PERSISTENT LIMESTONE BEDS.
MISSISSIPPIAN SYSTEM	MERAMECIAN SERIES		STE. GENEVIEVE FORMATION
			ST. LOUIS FORMATION
			SPERGEN FORMATION
	OSAGEAN SERIES		WARSAW FORMATION
			KEOKUK LIMESTONE
			BURLINGTON LIMESTONE

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GENERALIZED STRATIGRAPHIC COLUMN OF THE MISSISSIPPIAN AND PENNSYLVANIAN IN WAPELLO COUNTY upper middle series in the Mississippian System. This series consists of fossiliferous, gray to brown limestones and dolomites, white, gray, and brown chert, and two widespread glauconite zones in its upper portion. Stratigraphically overlying the Osage is the Meramec Series consisting of three units which in ascending order are: a sandy, micaceous dolomite; a limestone and dolomite sequence, with locally dominant sandstone and occasional concentrations of chert; and a fossiliferous limestone with red and green shale.

2.01232 The Pennsylvanian rocks were deposited in eastern Iowa as part of a great delta extending southwestward from across Illinois. The Cherokee Group of the Des Moines Series represents the oldest Pennsylvanian rocks in Wapello County. This group consists of alternating deposits of carbonaceous shale, clay, siltstone, sandstone, thick coal beds, and minor but persistent limestone beds.

2.0124 Cenozoic era. Southeastern Iowa was covered by the Kansan age glacial advance about 700,000 years ago. A thick blanket of glacial debris, including in some places a thin sheet of wind blown silt above the till, was deposited over the Mississippian and Pennsylvanian age bedrock. The drift sheet left by this advance consists of stratified and unstratified sand, silt, clay, pebbles, and boulders. In Wapello County these deposits vary thickness from about 25 to 170 feet, with the thinnest sections being found along the major drainageways.

2.01241 Windblown silt (loess) is found overlying the Kansan drift throughout most of the county, but is only dominant atop the highest uplands where it is around 5 feet thick and has not been removed by erosion.

2.01242 Recent alluvium is present as sand, silt, clay, and gravel in the flood plains of the Des Moines River and its tributaries. Remnants of older flood plains are recognized as terrace levels ranging from 8 to 50 feet above the present flood plain.

2.0125 Structural geology. Southeastern Iowa is situated in the Central Stable Region of the United States. It lies near the eastern edge of the Forest City Basin, a downwarped area with a northeast-southwest trending axis. This structure plunges to the southwest in Iowa which accounts for the slight southwestern regional dip in the southeastern part of the state. Superimposed upon this regional dip are numerous anticlines with axes trending northwest-southeast, parallel to the regional strike. Due to the difference in thickness of the Osage age sediments over the synclines and anticlines, these features are thought to have an age of deformation of before or around Early Mississippian. There are no faults recognized in or near Wapello County.

2.0126 Seismology. Iowa has a history of slight earthquake activity, with only two shocks of Intensity V or greater on the Modified Mercalli Scale epicentrally located within the state. However, 23 earthquakes with epicenters outside of Iowa have been felt in some portion of the state. There have been no earthquakes reported within 50 miles of the site.

2.01261 Iowa is located in Zone 1 of the U.S. Coast and Geodetic Survey's Seismic Risk Map for the United States. This designation indicates the possibility of an earthquake with an Intensity V or VI (MM) occurring in this area, or minor damage caused from a major distant disturbance.

2.013 Site Geology

2.0131 Topography. The Ottumwa Generating Station Unit 1 site is located southwest of the flood plain of the Des Moines River on a terrace cut into Kansan age till, northwest of Chillicothe in Wapello County, Iowa. Middle Avery Creek passes through the site flowing from the southwest to the northeast into the Des Moines River. The surrounding area is included in the hilliest part of Iowa with gently curving hillsides sloping to the terrace level of the valley. Maximum relief in the site area is approximately 100 feet, with the terrace level ranging from 25 to 35 feet above the flood plain which lies at an elevation of about 650 feet MSL.

2.0132 Soil and bedrock conditions. The following descriptions were obtained from the logs of the drilling program initiated to supply information concerning the general surface and subsurface conditions present at the site. Surficial deposits in the site area range in thickness from 41.5 feet on the high ground in the western part of the site, to 12.5 feet on the low ground along the flood plain of the Des Moines River. In the western part of the site and in the proposed main plant area on the terrace, the surficial deposits consist of brown and/or gray medium stiff to very stiff clayey soils overlying several feet of sand. The shallow soils are believed to be glacial tills while the deeper clays and sands are residual soils weathered from parent shales and sandstones. On the low ground along the Des Moines River flood plain the surficial deposits are composed of very soft to medium stiff clayey soil with some organic material, underlain by sands containing fine material. In these areas the shallow soils are relatively recent alluvial deposits and the deeper, cleaner sands are residual soils. The surficial material in the site area south of Avery Creek is again dark brown, soft to medium stiff clay or silty clay underlain by sand. The shallow soils just south of the creek are recent alluvium, the rest are glacial tills, with the deeper sands considered residual soils.

2.01321 The Pennsylvanian age bedrock was intercepted during the drilling program in the upland area in the northwestern part of the site. The Pennsylvanian rocks are primarily dark gray and black shales with occasional pyrite veins and thin coal seams plus gray siltstone and sandstone. The slope of the Pennsylvanian strata was observed to be up to 15 degrees in individual core samples.

2.01322 The Mississippian age rocks lie below the Pennsylvanian at depths from 40 to more than 80 feet below the surface in the northwestern upland area of the site. In the eastern and southern portions of the site these same rocks are present immediately below the soil cover, with dip to the north ranging from 0.1 to 0.4 degrees. Through much of the area the Mississippian rock sequence displays three prominant divisions: a 10 to 15 foot thick limestone believed to be the St. Genevieve Formation; an intermediate 10 to 20 foot thick sandstone unit underlain by a 20 foot or more thick limestone bed, the St. Louis Formation; and below this a sequence of dolomite and limestone thought to be the Spergen Formation.

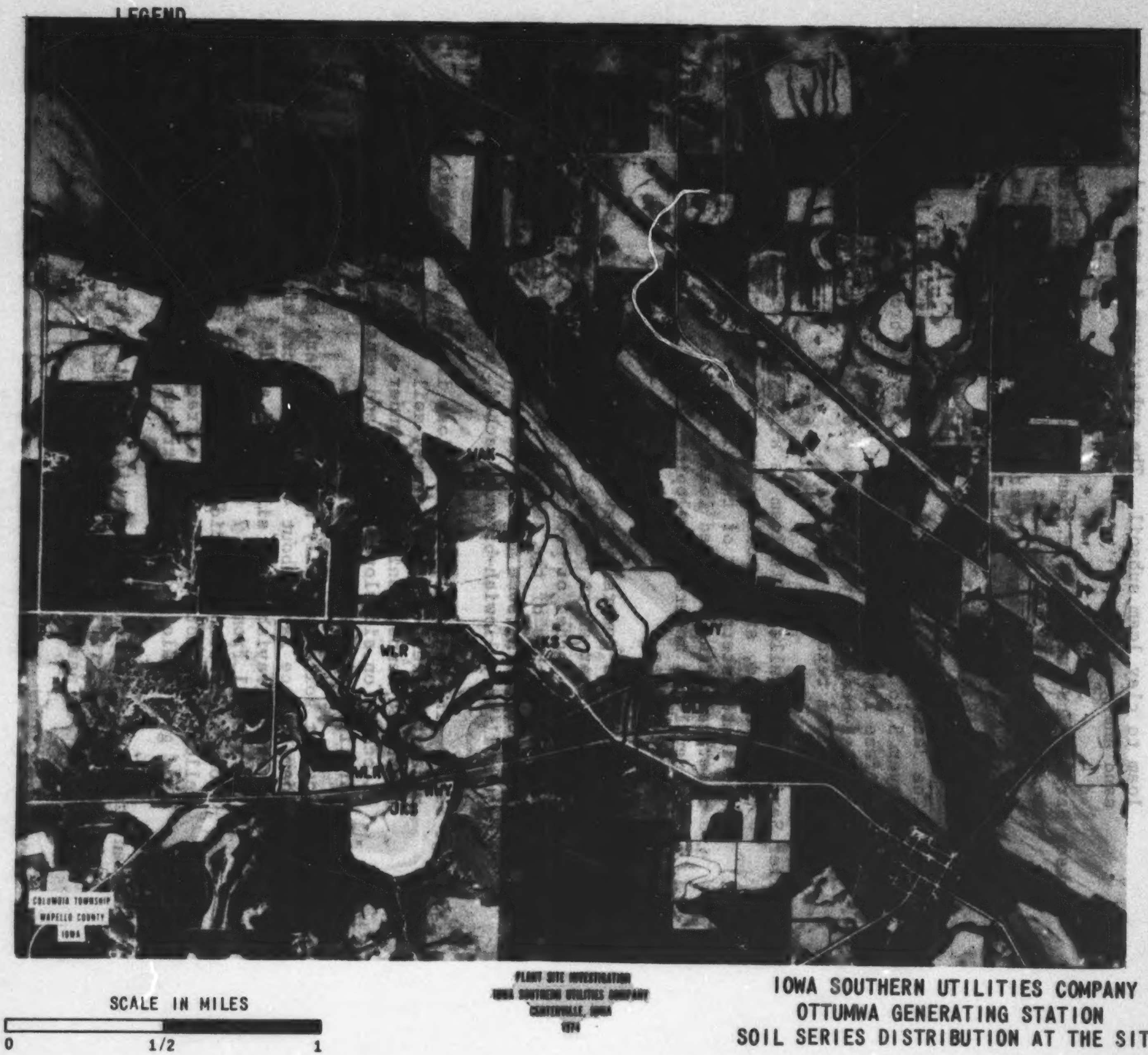
2.0133 Soil series. A map showing the soil series distribution in the site area is presented on Figure 2-3. The following descriptions were taken from the interpretations developed by Jeffrey G. Anliker, District Conservationist in cooperation with Wapello County Soil Conservation District.

Nodaway Series--The Nodaway silt loam occurs on the flood plain of the Des Moines River and Middle Avery Creek. It consists of moderately well-drained, silty, bottomland soils that have developed in recently deposited, stratified, silty alluvium on first bottomlands. These soils are nearly level with a typical 0 to 2 per cent slope, but some areas may be slightly undulating due to remnants of the old meandering stream channel.

Nodaway soils usually have a dark grayish-brown silt loam surface layer about 7 inches thick, beneath which is a stratified, grayish-brown and dark grayish-brown silt loam containing a very few thin strata of silty clay loam that extends to a depth of more than 60 inches.

Marshan, Deep Series--The Marshan clay loam, deep, occurs on the terrace of the Des Moines River. This soil type has sand and gravel at 32 to 40 inches and are leached of carbonates. It is dark colored, poorly-drained loamy soils developed in glacial outwash and alluvium under prairie vegetation. It occurs on stream terraces and nearly level upland outwash areas.

The Marshan soils have a black, gritty, silty clay loam surface layer 22 inches thick with a dark-gray, moderately permeable



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SOIL SERIES DISTRIBUTION AT THE SITE

FIGURE 2-3

loam to clay loam subsoil. The substratum is mottled grayish-sand and gravel.

Jackson Series--The Jackson silt loam consists of light-colored, moderately well to somewhat poorly drained silty soil developed under forest vegetation from silty alluvium. It is present on low stream terraces generally above the present flood plain.

The Jackson soils have a dark grayish-brown, silt loam surface layer 3 to 6 inches thick and a grayish-brown silt loam subsurface layer. The subsoil is a moderately permeable, mottled grayish-brown silty clay loam with a similarly colored but silt loam textured substratum.

Weller Series--The Weller silt loam is a light colored, moderately well-drained, silty soil present in the northern, western, and southeastern part of the site area. It is formed in moderately fine textured loess under a vegetation of trees on gently to moderately sloping sideslopes and gently sloping convex ridges.

Weller soils generally have a dark grayish-brown silt loam surface layer about 7 inches thick with a subsurface layer of about 5 inches of brown silt loam with platy structure. Below 12 inches of the subsoil is yellowish-brown silty clay loam containing some mottles in the lower part. The lower subsoil is yellowish-brown, leached, silty clay loam.

Gosport Series--The Gosport silty clay loam is a light-colored, moderately well-drained, clayey soil. It has formed in weathered Pennsylvanian shales under a vegetation of trees. It occurs on sideslopes, and upland escarpments which often parallel major streams.

Gosport soils typically have a very dark gray, silty clay loam surface layer about 4 inches thick, with a subsurface layer of grayish-brown silty clay about 3 inches thick. The subsoil from about 7 to 27 inches is brown to grayish-brown, very strongly acid, silty clay or clay with distinct yellow-brown mottles and shale fragment with an extremely acid gray shale and clay substratum.

Camden Series--The Camden silt loam is a light-colored, well drained, medium textured soil present developed in alluvium under forest on nearly level to moderately sloping stream terraces.

The Camden soils have a dark grayish-brown silt loam surface 2 to 4 inches thick underlain by a subsurface layer of grayish-brown silt loam. The subsoil is a moderately permeable, dark-yellowish-brown, silt clay loam increasing in sand with depth. The lower subsoil is a yellowish-brown sandy loam at 36 to 45 inches with a loamy sand substratum.

Waukee, Uplands Series—The Waukee loam of the uplands is a dark-colored, well-drained, medium textured soil with sands at about 3 feet, developed from water laid outwash material in the uplands beneath prairie vegetation.

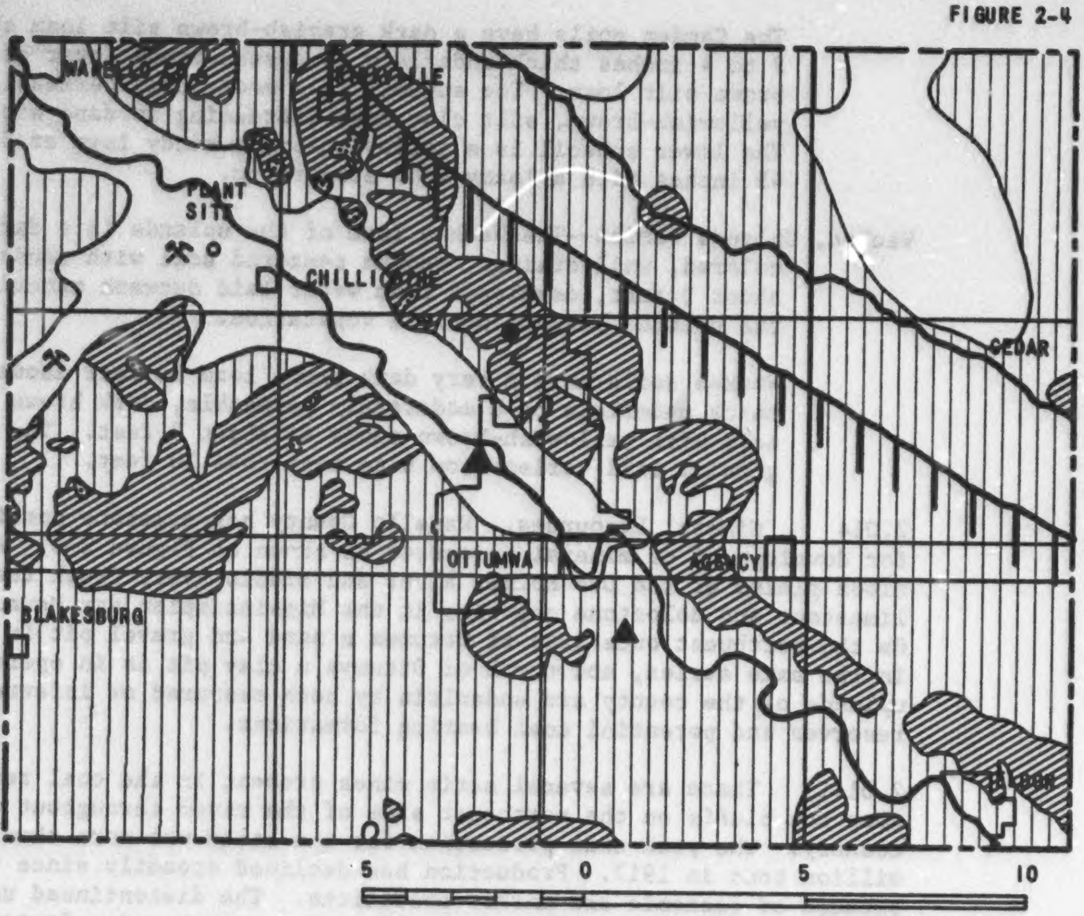
Waukee soils have a very dark brown loam surface about 14 inches thick underlain by a moderately permeable, dark brown loam subsoil with yellowish-brown sands at about 3 feet. The depth to glacial till varies from 8 to more than 20 feet.

2.014 Mineral Resources. Wapello County has numerous possibilities for development of mineral resources as shown on Figure 2-4. Along the flood plains of the Des Moines River and Middle Avery Creek there are limestone and dolostone quarries in the Mississippian age Meramec Series. On the northwest outskirts of Ottumwa a sand and gravel pit is developed in the same series, and north of Ottumwa a clay pit is in operation. The uplands of the county are underlain by both measured or inferred coal reserves and potential coal bearing formations.

2.0141 There are several strip mines present in the coal reserves near the bluffs on the northeast side of the river throughout the country. The peak coal production for the state was more than nine million tons in 1917. Production has declined steadily since then because of economic and market conditions. The discontinued use of coal by the railroads and many domestic users were major factors in reduced market demand.

2.0142 Three-fourths of the county is underlain by the northeastern edge of a zone of potential gypsum and anhydrite deposits of Mississippian age, and the entire county overlies similar deposits in Devonian age formations.

FIGURE 2-4



⚒ QUARRIES

▲ SAND AND GRAVEL PITS

● CLAY PITS

▩ COAL STRIP MINES

▨ AREAS UNDERLAIN BY MEASURED OR INFERRED COAL RESERVES.

▥ AREAS UNDERLAIN BY POTENTIALLY COAL BEARING ROCK FORMATIONS.

⋿ AREAS UNDERLAIN BY POTENTIAL GYPSUM AND ANHYDRITE DEPOSITS IN MISSISSIPPI AGE FORMATIONS.

SOURCE: IOWA GEOLOGICAL SURVEY MISCELLANEOUS MAP SERIES 4, 1973.

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MINERAL RESOURCES OF WAPELLO COUNTY

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2.02 Hydrology

2.021 Introduction. This section is a summary of the surface water and ground water hydrology for Iowa Southern Utilities Company Ottumwa Generating Station Site, based on available literature and records. No records are available for the site itself. The surface water and ground water include information on the present resources, quality, and use of the water in the vicinity of the site.

2.022 Surface Water. The Ottumwa Generating Station site is located on a terrace adjacent to the flood plain of the Des Moines River in Wapello County, Iowa between River Miles 104 and 107. Middle Avery Creek passes through the site flowing from the southwest to the northeast into the Des Moines River between River Miles 105 and 106.

2.0221 The Des Moines River will be the primary source of water for the Ottumwa Generating Station.

2.0222 The Des Moines River originates in Murray County in Southern Minnesota and enters the Mississippi River just south of U.S. Lock & Dam No. 19. The drainage basin of the river is long and narrow having a fairly regular outline and lateral boundry with a total area at the mouth of 14,467 square miles. Figure 2-5 shows a location plan for the site and for the drainage basin of the Des Moines River. At the site the Des Moines River has 13,323 square miles of controlled drainage area and approximately 870 square miles of uncontrolled. Control has been maintained since 1969 by the Corp of Engineers with Red Rock Dam and Reservoir. Saylorville Dam and Reservoir which is presently under construction will aid Red Rock in controlling flow in the river upon its completion.

2.0223 The operational plan for Red Rock Dam and Reservoir has been set up to limit releases to a discharge of 30,000 cfs at Ottumwa during the nongrowing season (December 16 to April 20) and 18,000 cfs during the growing season (April 21 to December 15). Release during drought periods will augment a minimum discharge of 300 cfs at Ottumwa.

2.0224 Table 2-1 summarizes the mean and minimum flows on a monthly and yearly basis since Red Rock Dam and Reservoir has been in operation. The maximum discharge, during this period was 33,600 cfs on May 2, 1973, and the minimum daily discharge was 54 cfs on September 16, 1971.

2.0225 Figure 2-6 shows an anticipated discharge-frequency curve of the Des Moines River at Ottumwa as modified by Red Rock and Saylorville Dams and Reservoirs.

TABLE 2-1

MONTHLY AND YEARLY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF DES MOINES RIVER AT OTTUMWA

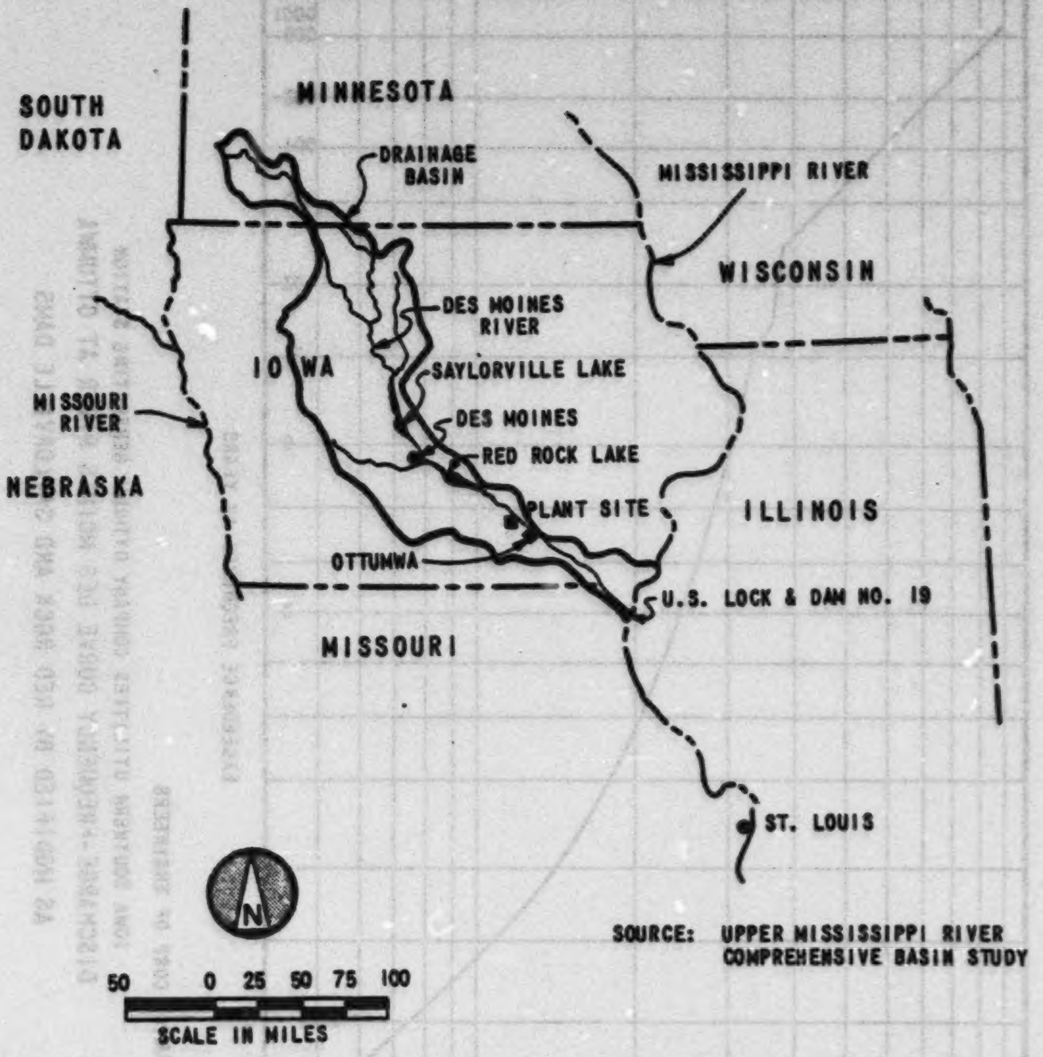
WATER YEAR	1969	1970	1971	1972	1973
OCT	5,078	1,962	4,387	367	5,789
NOV	4,699	2,137	3,383	1,659	13,810
DEC	1,851	1,231	2,872	1,562	5,519
JAN	1,743	1,008	1,216	825	12,380
FEB	1,969	1,580	9,387	913	16,470
MAR	7,807	6,132	18,600	4,709	16,770
APR	20,660	7,664	9,711	3,094	24,570
MAY	14,640	9,999	5,462	10,750	24,800
JUNE	17,520	4,667	6,594	8,760	19,180
JULY	16,730	1,363	4,353	6,014	19,600
AUG	17,110	2,687	953	9,700	17,380
SEPT	6,214	2,824	439	7,737	7,012
WATER YEAR	9,703	3,613	5,589	4,688	15,250
CALENDER YEAR	2,035	9,175	4,061	4,995	6,477

SOURCE: WATER RESOURCES DATA FOR IOWA 1974

IOWA SOUTHERN UTILITIES COMPANY OTTUMWA GENERATING STATION

MEAN MONTHLY AND ANNUAL FLOWS
DES MOINES RIVER AT OTTUMWA
SINCE RED ROCK DAM AND
RESERVOIR HAS BEEN IN OPERATION

FIGURE 2-5

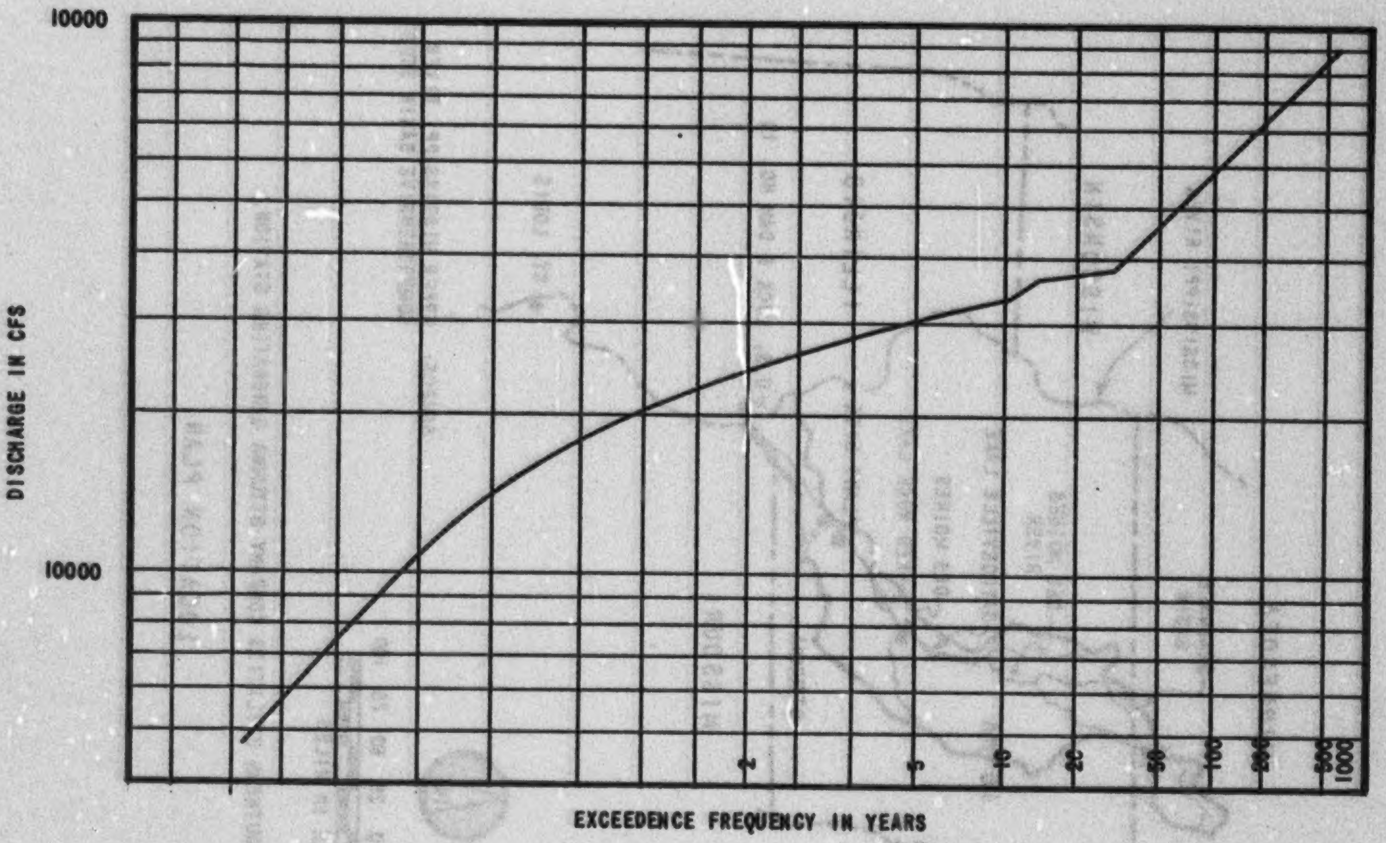


SOURCE: UPPER MISSISSIPPI RIVER COMPREHENSIVE BASIN STUDY

IOWA SOUTHERN UTILITIES COMPANY OTTUMWA GENERATING STATION

LOCATION PLAN

FIGURE 2-6



SOURCE: U.S. ARMY, CORP OF ENGINEERS

IOWA SOUTHERN UTILITIES COMPANY OTTUMWA GENERATING STATION
DISCHARGE-FREQUENCY CURVE DES MOINES RIVER AT OTTUMWA
AS MODIFIED BY RED ROCK AND SAYLORVILLE DAMS

2.0226 Saylorville Reservoir is not yet operational. Construction on the dam embankment was completed in October 1975; however, additional construction remains before the project will be finished and available for complete utilization. Construction activities presently are underway at the proposed recreation areas.

2.0227 Preliminary plans have been developed for operating Saylorville Reservoir. Conservation objectives will be to augment Des Moines River flows during low-flow periods while maintaining a steady pool for recreation at 833 feet MSL, during normal periods. Minimum flows will be maintained of 200 cfs at Des Moines and 300 cfs at Ottumwa.

2.0228 Since a minimum flow of 300 cfs presently is maintained at Ottumwa, the completion and operation of Saylorville Reservoir will not affect planning for the Ottumwa Generating Station.

2.0229 Extreme flows have occurred on the Des Moines River. Mean discharges during the 1947 water year was the highest on record (9,660 cfs at Tracy) while the mean discharge during the 1956 water year was the lowest on record (496 cfs at Tracy). Figure 2-7 shows hydrographs for the 1947 and 1956 water years at Tracy and how they might have been altered by the operation of Red Rock Dam.

2.02210 Figures 2-8, 2-9, and 2-10 show the daily-discharge duration curve, minimum average flow curve and magnitude-frequency curve for the Des Moines River period at Ottumwa. The 90 per cent maximum flow value of daily discharge was 397 cfs and the 10-year, 7-day low flow was 100 cfs.

2.02211 The quality of the Des Moines River water at the site can be approximated from the chemical analysis and temperature measurements taken at Ottumwa. Concentrations of dissolved solids are highest during periods of low discharge and lowest during high discharges.

2.02212 Table 2-2 shows chemical analysis of the Des Moines River water at Ottumwa (1956-1968). Other water quality data are given in section 2.06. Table 2-3 summarizes the mean and minimum monthly water temperatures of the Des Moines River at Ottumwa (1969-75) since Red Rock Dam and Reservoir has been in operation.

2.023 Ground Water. The Ottumwa Generating Station is underlain by three sedimentary bedrock aquifers and is adjacent to the alluvial aquifer underlying the flood plain of the Des Moines River.

2.0231 Figure 2-11 shows the hydrological bedrock units map for Wapello County and Figure 2-12 shows a generalized hydrological bedrock units cross-section cut perpendicular to the Des Moines River below the site.

Dissolved constituents and hardness in milligrams per liter. Analysis by State Hygienic Laboratory of Iowa

Date Collected	Discharge (cfs)	Temperature		Silica (SiO_2)	Iron (Fe) Soluble	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids	Hardness as $CaCO_3$	Phosphate (PO_4) Total	Organic Nitrogen	Chemical Oxygen Demand (C.O.D.)	Specific Conductance (Micromhos at 25 C)	pH
		F	C																				
6-18-56	609	86	29	9.8	0.08	*	61	20	21	5.4	190	2.4	105	20	0.4	8.0	391	234	1.9	1.6	58	546	8.0
10-08-56	170	63	17	1.2	.20	0.04	52	29	33	6.2	178	0	128	30	.3	.09	393	250	1.1	.93	36		8.0
2-04-57	222	37	2.8	6.0	.30	1.0	99	38	67	7.7	368	0	149	73	.2	3.5	671	402	4.2	1.8	50	1110	8.3
5-27-57	2,060	70	21	6.0	.12	*	50	25	18	4.6	176	0	86	18	.4	13	351	230	.90	2.1	58	529	8.0
9-09-57	650	70	21	.8	.10	*	57	25	25	5.2	178	4.8	111	21	.35	.44	373	246	.96	1.1	25	578	8.3
10-21-57	321	59	15	4.0	.16	.17	67	22	28	6.2	215	2.4	109	27	.35	2.7	387	260	1.0	1.4	26	625	8.2
1-06-58	1,000	30	-1.1	10	.06	*	114	38	27	3.9	359	6.0	146	23	.50	20	601	446	.98	1.0	35	865	8.4
4-21-58	2,120	64	18	.9	.14	.05	66	32	16	3.1	193	9.6	117	14	.40	16	420	296	.83	1.2	34	594	8.4
6-30-58	2,070	79	26	13	.32	*	55	30	15	2.8	161	4.8	106	14	.40	8.9	360	260	.80	1.6	25	546	8.1
3-02-59	6,560	35	1.7	6.8	1.1	*	37	11	5	12	129	0	37	6	.30	4.4	277	148	3.7	3.8	160	320	7.7
6-01-59	37,200	66	19	14	2.0	*	40	13	4.2	4.2	137	0	43	4	.30	12	270	154	3.9	2.4	75	306	7.9
8-24-59	898	88	31	5.2	.02	*	76	16	16	4.4	215	6.0	82	7.5	.40	.44	385	256	.96	.63	39	505	8.3
11-23-59	1,930	33	.6	3.2	.08	*	64	29	18	4.5	193	7.2	111	20	.40	2.2	393	280	.86	.73	29	595	8.5
2-15-60	3,350	32	0	12	.06	.22	84	20	14	3.4	262	0	104	14	.35	13	437	296	.69	.55	8	639	7.8
4-11-60	20,900	44	6.7	16	.10	*	66	19	5.6	3.6	200	0	66	6	.35	19	362	242	1.8	1.8	49	490	8.0
6-27-60	7,000	73	23	22	.06	*	86	24	8.8	2.9	251	7.2	75	8	.55	24	341	312			44	612	8.2
9-26-60	10,000	64	18	10	.14	*	27	11	5.2	5.0	100	0	31	7	.45	7.1	241	112	4.7	2.2	72	253	8.1
1-03-61	700	32	0	10	.10	.34	126	39	30	3.8	388	1.2	169	28	.35	5.8	631	476	13	1.2	36	937	8.1
5-29-61	5,310	66	19	11	.04	*	93	32	11	2.8	259	14	108	9	.55	19	462	364	1.0	1.0	33	664	8.4
11-27-61	6,400	42	5.6	19	.06	*	88	26	11	2.6	273	4.8	85	9	.35	13	498	328	1.3	1.0	17	635	8.1
1-29-62	2,700	32	0	18	.12	.29	97	30	17	2.8	322	0	119	16	.35	11	487	366		.47		729	7.6
6-03-63	4,680	73	23	14	.06	*	91	28	13	2.6	284	4.8	76	11	.35	18	474	364	.80	.85	26	656	8.1
2-03-64	490	32	0	8.2	.08	.45	94	31	39	4.8	273	17	124	28	.35	5.3	527	364	2.3	2.3	48	527	8.4
8-31-64	1,450	77	25	4.0	.12	.12	64	22	19	5.8	205	0	99	19	.35	.9	359	252	1.0	1.1	39	567	7.8
6-07-65	22,600	68	20	16	1.3	.14	61	14	5.6	2.8	178	0	65	6	.35	17	460	228	4.6	6.4	175	427	8.0
3-28-66	5,000	45	7	16	.16	*	85	20	12	3.8	242	0	86	14	.30	7.1	397	296	1.4	1.9	54	611	8.0
4-03-67	2,440	57	14	9.5	.36	.40	53	16	18	7.0	150	0	83	14	.40	3.9	322	196	1.6	1.3	35	470	7.6
7-10-67	5,780			21	.10	*	104	25	12	3.2	300	0	96	16	.45	23	482	364	1.0	.47	28	740	8.2
1-08-68	155	36	2	4.0	.26	1.2	103	36	50	5.8	332	0	170	45	.3	1.9	613	404				910	8.2
5-06-68	1,630										140	0		29		5.8	352		1.9	2.1	9.9	540	8.2
RANGE		High		22	2.0	1.2	126	39	67	12	388	17	170	73	0.55	24	671	476	13	6.4	175	1100	8.5
		Low		.8	.02	*	27	11	4.2	2.6	100	0	31	4	.2	.44	241	112	.80	.47	8	253	7.6

* Less than 0.05.

Source: Water Resources of Southeast Iowa

Iowa Southern Utilities Company - Ottumwa Generating Station
CHEMICAL ANALYSES OF DES MOINES RIVER WATER AT OTTUMWA

Table 2-2

TABLE 2-3

Mean and Minimum Discharge in Cubic Feet Per Second of the Des Moines River at Ottumwa

Water Year	1969		1970		1971		1972		1973		1974		1975	
	Mean	Min	Mean	Min	Mean	Min	Mean	Min	Mean	Min	Mean	Min	Mean	Min
Oct	5,078	1,250	1,962	1,020	4,387	656	367	240	5,789	2,700	18,390	15,200	599	485
Nov	4,699	3,430	2,137	1,200	3,383	1,280	1,659	715	13,810	7,830	11,530	4,720	2,069	1,050
Dec	1,851	900	1,231	751	2,872	1,500	1,562	385	5,519	2,900	10,830	5,200	1,874	539
Jan	1,743	1,000	1,008	500	1,216	600	825	520	12,380	5,600	8,768	4,000	1,368	600
Feb	1,969	1,220	1,580	800	9,387	900	913	450	16,470	7,200	9,054	4,600	1,316	870
Mar	7,807	1,720	6,132	1,330	18,600	9,360	4,709	2,640	16,770	6,510	12,850	6.990	7,470	941
Apr	20,660	4,790	7,664	4,980	9,711	4,490	3,094	1,630	24,570	15,400	12,650	6,870	16,430	12,900
May	14,640	4,890	9,999	3,420	5,462	3,410	10,750	5,840	24,800	18,100	15,230	8,010	11,860	5,630
June	17,520	16,200	4,667	2,450	6,594	2,750	8,760	4,070	19,180	17,900	18,590	15,400	16,640	13,600
July	16,730	6,520	1,363	1,050	4,353	2,150	6,014	2,310	19,600	18,300	15,590	9,030	9,334	1,530
Aug	17,110	16,100	2,687	499	953	346	9,700	2,740	17,380	13,700	4,873	1,570	1,808	709
Sept	6,214	1,740	2,824	322	439	54	7,737	1,340	7,012	3,460	1,035	571	1,939	740
Water Year	9,703	900	3,613	322	5,589	54	4,688	240	15,250	2,700	11,640	571	6,064	485
Calender Year	2,035	100	9,175	751	4,061	322	4,995	54	6,477	450	16,640	3,460	8,594	485

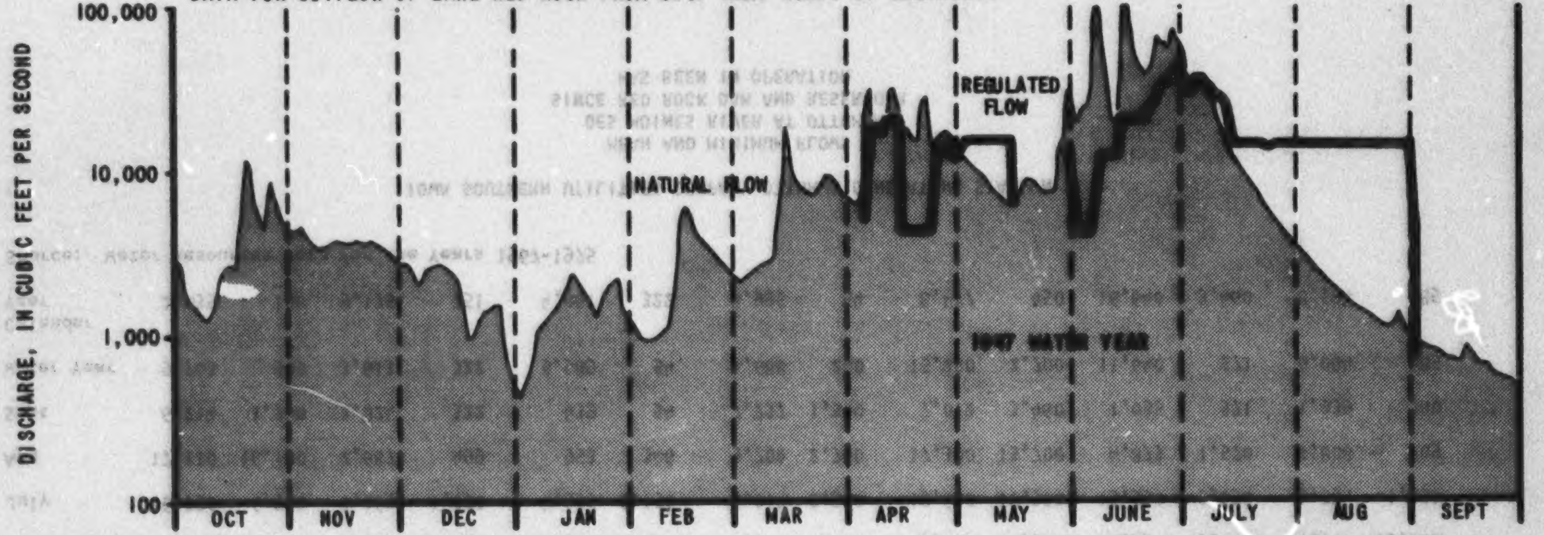
Source: Water Resources Data for the Years 1967-1975

IOWA SOUTHERN UTILITIES COMPANY OTTUMWA GENERATING STATION

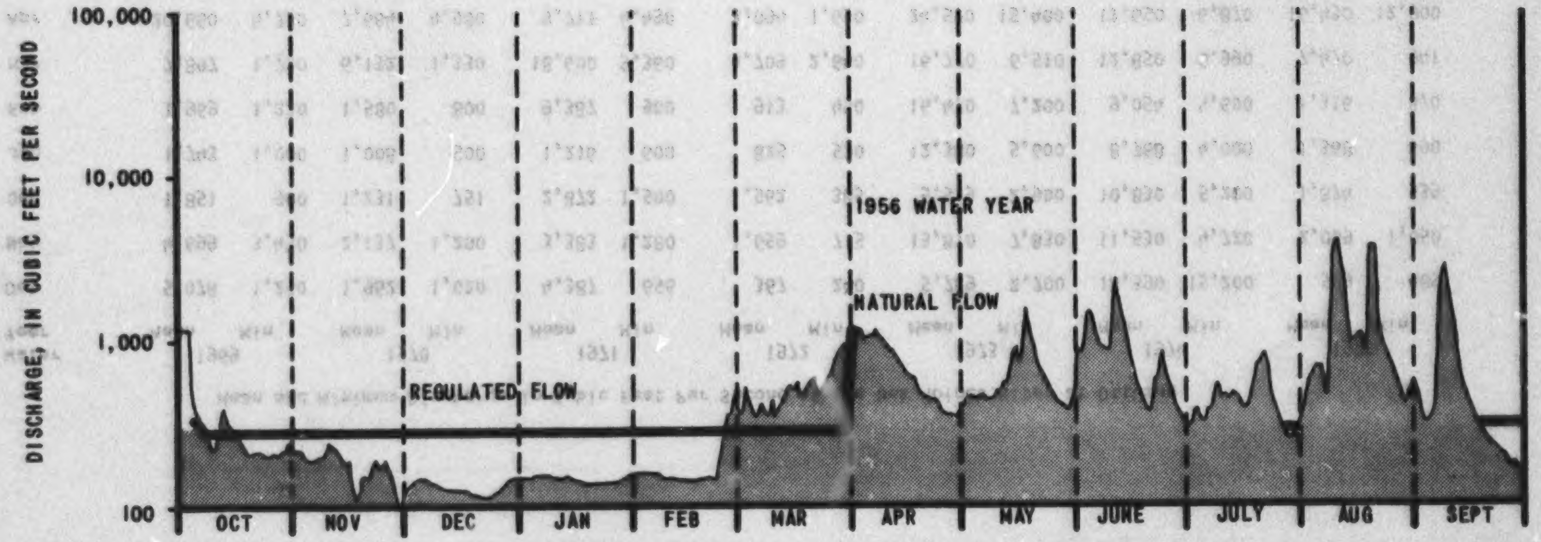
MEAN AND MINIMUM FLOWS
DES MOINES RIVER AT OTTUMWA
SINCE RED ROCK DAM AND RESERVOIR
HAS BEEN IN OPERATION

FIGURE 2-7

DATA FOR OUTFLOW OF LAKE RED ROCK FROM U.S. ARMY CORPS OF ENGINEERS



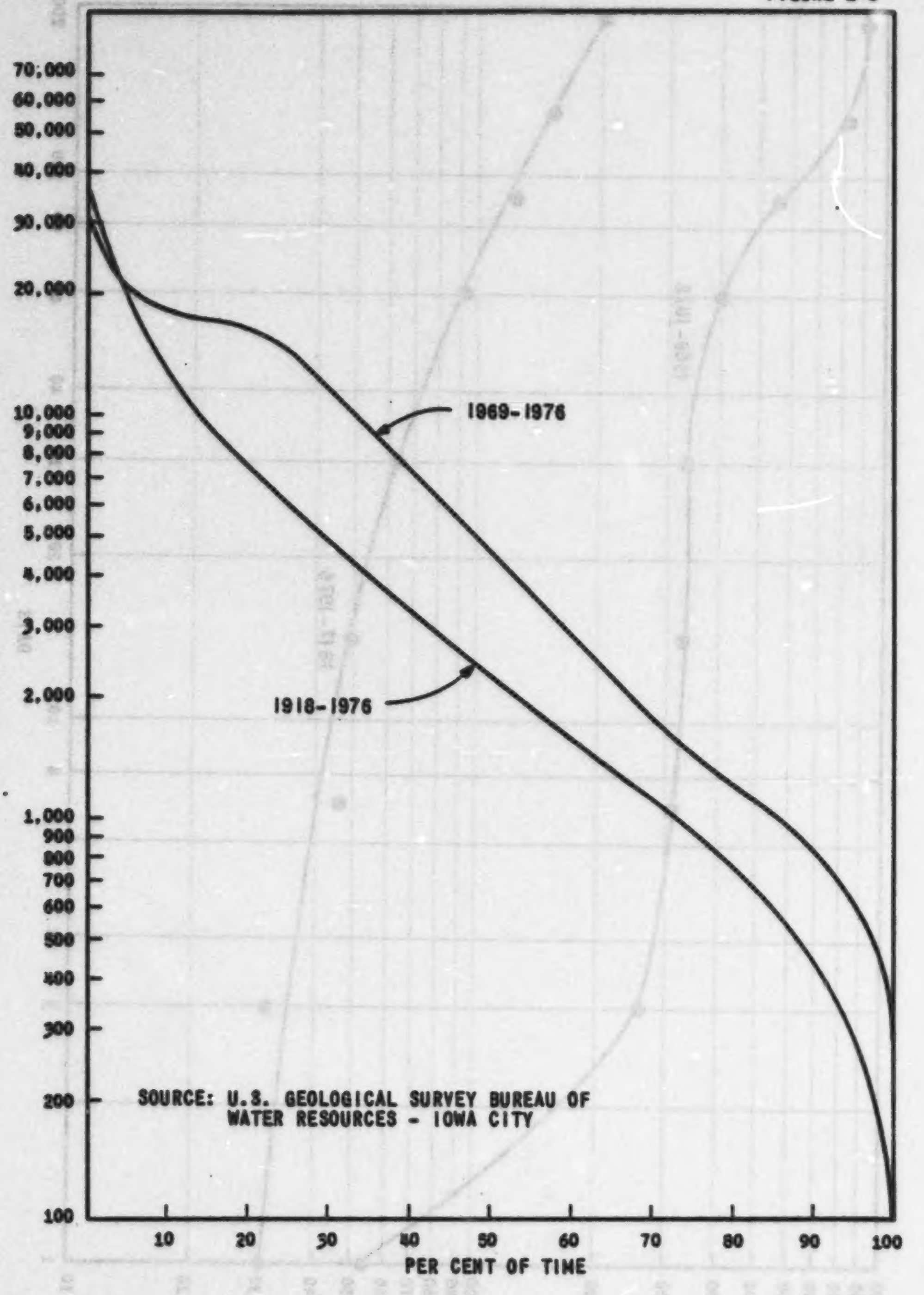
SOURCE: THE WATER RESOURCES OF SOUTHEAST IOWA



IOWA SOUTHERN UTILITIES COMPANY OTTUMWA GENERATING STATION

HYDROGRAPHS FOR 1947 AND 1956 WATER YEARS AT TRACY
ALTERED BY THE OPERATION OF RED ROCK DAM

FIGURE 2-8

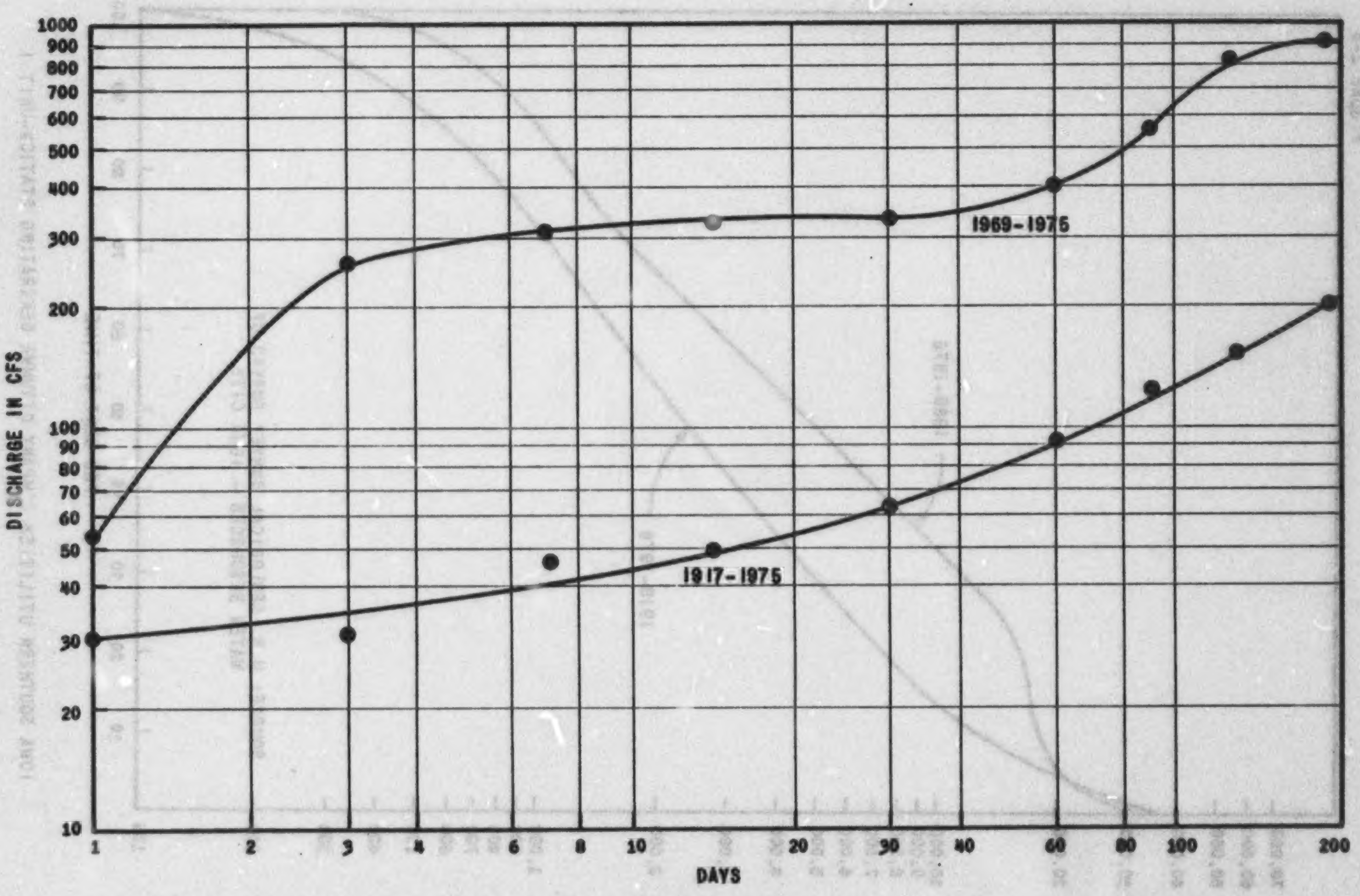


SOURCE: U.S. GEOLOGICAL SURVEY BUREAU OF WATER RESOURCES - IOWA CITY

IOWA SOUTHERN UTILITIES COMPANY OTTUMWA GENERATING STATION-UNIT I

DAILY-DISCHARGE DURATION CURVE
(1918-1976)

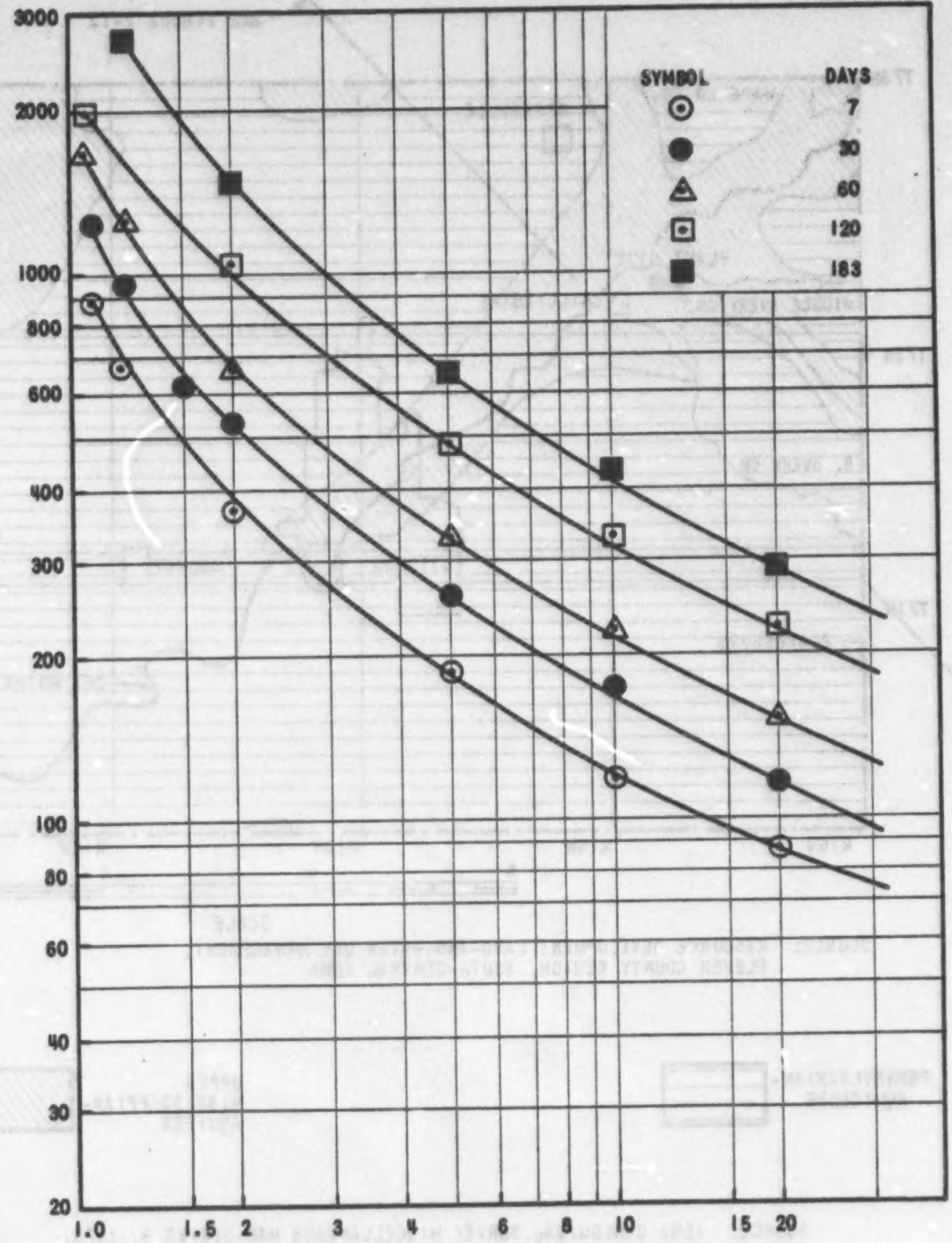
FIGURE 2-9



SOURCE: U.S. GEOLOGICAL SURVEY-BUREAU OF WATER RESOURCES, IOWA CITY.

MINIMUM AVERAGE FLOW FOR DES MOINES RIVER AT OTTUMWA, IOWA (MARCH 1917 TO SEPTEMBER 1975)

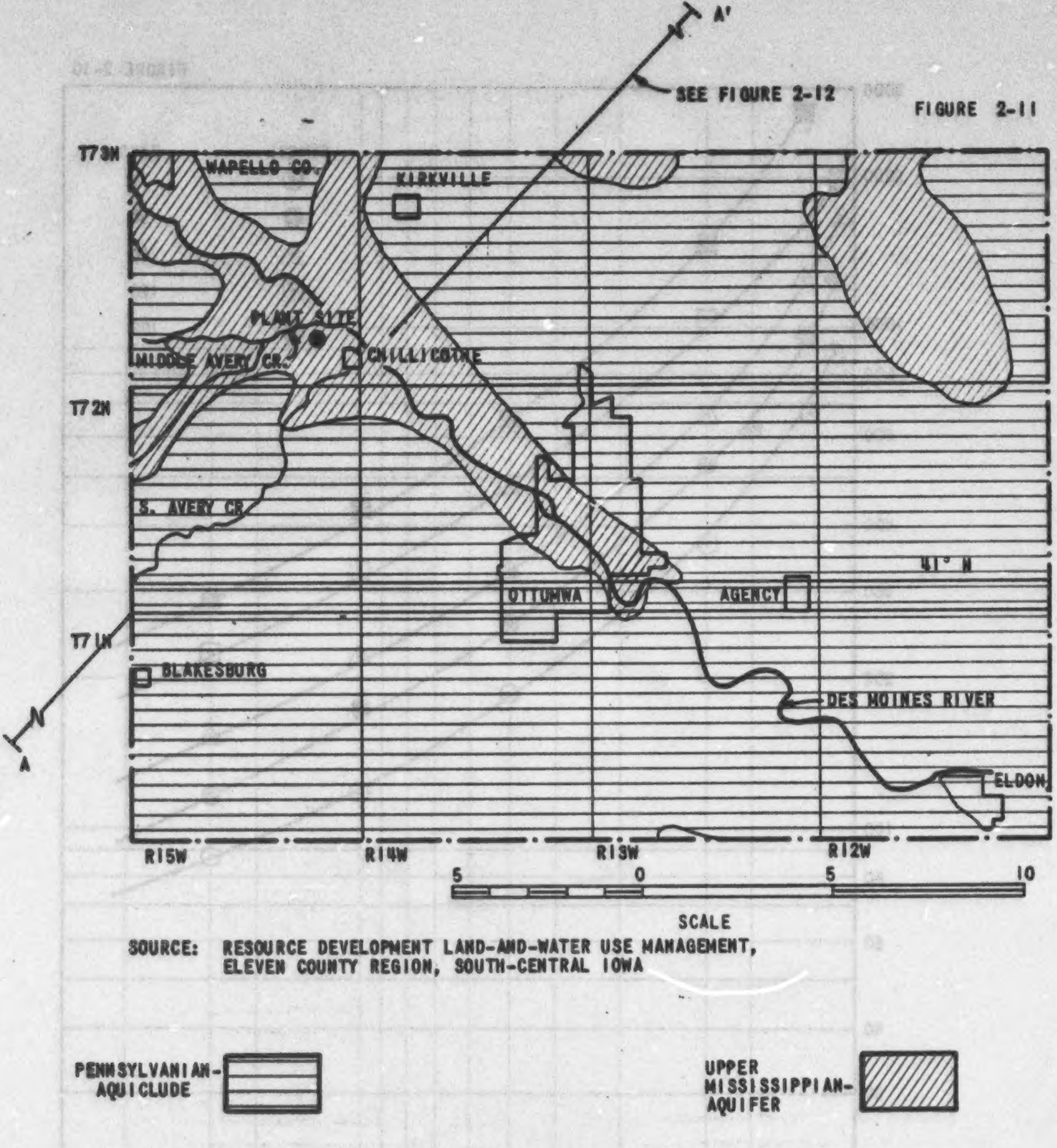
FIGURE 2-10



SOURCE: U.S. GEOLOGICAL SURVEY-WATER RESOURCES DIVISION, IOWA CITY.
IOWA SOUTHERN UTILITIES COMPANY OTTUMWA GENERATING STATION-UNIT I

MAGNITUDE AND FRQUENCY OF ANNUAL LOW FLOWS
FOR DES MOINES RIVER AT OTTUMWA, IOWA (1917-1971)

FIGURE 2-11

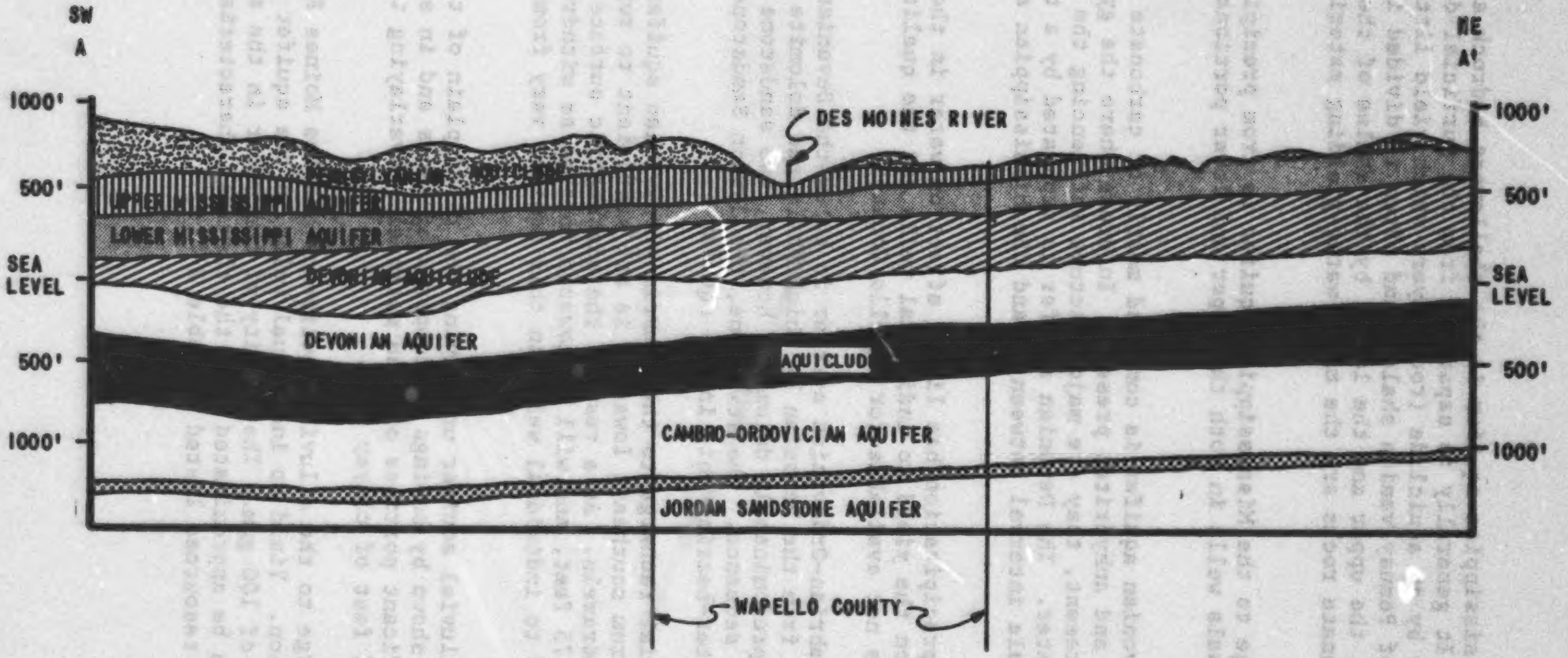


SOURCE: RESOURCE DEVELOPMENT LAND-AND-WATER USE MANAGEMENT, ELEVEN COUNTY REGION, SOUTH-CENTRAL IOWA

SOURCE: IOWA GEOLOGICAL SURVEY MISCELLANEOUS MAP SERIES 4, 1973.

IOWA SOUTHERN UTILITIES COMPANY OTTUMWA GENERATING STATION

HYDROLOGICAL BEDROCK UNITS MAP-WAPELLO COUNTY



SOURCE: RESOURCE DEVELOPMENT LAND-AND-WATER USE MANGEMENT, ELEVEN COUNTY REGION, SOUTH-CENTRAL IOWA

IOWA SOUTHERN UTILITIES COMPANY OTTUMWA GENERATING STATION

HYDROLOGICAL BEDROCK UNITS MAP

FIGURE 2-12

2.0232 The Mississippian aquifer is the shallowest bedrock aquifer in Wapello County. It generally is separated from the surficial deposits within the county by an aquiclude (rock layers which yield little or no water to wells) of Pennsylvanian shales, and often is divided into two distant aquifers, the upper and the lower, by the shales of the Warsaw Formation. Carbonate rocks are the major water-yielding material in the aquifer.

2.0233 Recharge to the Mississippian aquifer is from precipitation. Yield to individuals wells in both the upper and lower portions is less than 20 gpm.

2.0234 The Devonian aquifer is composed mostly of carbonate rocks with some gypsum and anhydrites present. In areas where the gypsum and anhydrites are present, they are major factors influencing the chemical quality of the water. The Devonian aquifer is separated by a thick predominantly shale interval between it and the Mississippian aquifer above.

2.0235 Local precipitation has little effect on water in the Devonian aquifer. Data on the yield to individual wells and the quality of water in the aquifer is not available for Wapello County.

2.0236 The Cambrian-Ordovician aquifer is below the Devonian aquifer and is separated from the Devonian by thick shale and dolomite layers. This aquifer is predominantly dolomite, however, two sandstone units occur within the sequence. The lower one, the Jordon Sandstone, is the principal water-bearing unit in the aquifer.

2.0237 Potential recharge to the Cambrian-Ordivician aquifer is more than 100 miles from southeast Iowa and is not sufficient to replenish the present withdrawals. As a result, the piezometric surface has depressed 25 to 75 feet, and will be lowered further as withdrawals continue. Yield to individual wells in this aquifer vary from 500 to 1000 gpm.

2.0238 The alluvial aquifer underlying the flood plain of the Des Moines River as shown by borings is composed of sands and in some locations significant portions of fine material. Overlaying these sands is 9 to 12 feet of clayey soil.

2.0239 Recharge to the alluvial aquifer of the Des Moines River is from precipitation. Yield to individual wells in the aquifer should be in the order of 100 gpm. The quality of the water in the aquifers listed above can be approximated from the chemical characteristics of ground water resources listed in Table 2-2.

2.024 Water Use. Water withdrawals from surface water sources in Wapello County for 1967-1968 were as follows (in mgd): farm ponds-0.27; streams-5.22; alluvium-0.13.

2.0241 During the sampling period the following withdrawals of ground water were made: glacial drift and buried channels-0.56; shallow bedrock-0.30; Cambrian-Ordovician-5.91. The total withdrawn from all sources was 12.39.

2.0242 The largest single location of withdrawals was at Ottumwa where municipal supply was withdrawn from the Des Moines River and where industry withdrew the largest portion of withdrawals from the Cambrian-Ordovician aquifer. In 1966-1967 Ottumwa's withdrawals amounted to 10.08 mgd. Total withdrawals in Wapello County average only 12.39 mgd for the period.

2.0243 The Iowa Natural Resources Council is responsible for the allocation of water resources within the state. Table 2-4 lists permits which have been issued for withdrawal of water from the Des Moines River Basin between Lake Red Rock and Ottumwa, Iowa. Pending applications for permits to withdraw water are also shown.

2.0244 The Iowa Natural Resources Council together with the U.S. Corps of Engineers currently are conducting studies concerning the allocation of water including the Des Moines River. Ultimately, the Natural Resources Council will make a decision on the permit application for the Ottumwa Generating Station.

Table 2-4

REGULATED STREAM WITHDRAWALS IN THE DES MOINES RIVER BASIN BETWEEN LAKE RED ROCK AND OTTUMWA, IOWA

Name	Permit No.	County	Location*	Source	Type of Use	Annual Amount Authorized (acre-feet)	Maximum Withdrawal Rate (cfs)	Withdrawal Period
A. Existing Permits								
1. Iowa Southern Utilities (Bridgeport Station)	578-R1	Wapello	7-73-15	Des Moines River	Power Production	1,726	6.7	Jan. 1 - Dec. 31
2. Material Service, Inc.	2291	Wapello	23-72-14	Des Moines River	Sand & Gravel Production	600**	4.5	Apr. 1 - Nov. 15
3. Durham Quarry, Inc.	2974	Marion	29-76-18	Des Moines River	Irrigation	240	4.5	Apr. 1 - Oct. 1
B. Pending Applications								
1. Iowa Southern Utilities (Ottumwa Station)		Wapello	26-73-15	Des Moines River	Power Production	14,499	20	Jan. 1 - Dec. 31
2. Pella Sand & Gravel Company		Marion	3-75-18	Des Moines River	Sand & Gravel Production	2,099**	13.4	Mar. 1 - Dec. 15

*Location given as section-township-range.

**Water use is basically non-consumptive.

Source: Iowa Natural Resources Council, June 1976.

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2.03 Meteorology

2.031 Regional Climatology

2.0311 General. Iowa lies near the geographic center of the 48 contiguous states. It is primarily rolling prairie and is approximately equidistant from the Gulf of Mexico, the Atlantic Ocean, and the Hudson Bay at roughly 900 miles distance each. The Pacific Ocean is about 1300 miles west and the Rocky Mountains are approximately 500 miles west of Iowa. Iowa's climate is distinctly continental with a wide variety of weather extremes and marked seasonal variations. Oscillations and perturbations in the high level prevailing westerlies have an important affect on Iowa's weather. These high level features influence surface weather systems and cause surface winds to flow predominantly from either the south to southeast or the north to northwest. The southerly winds can draw warm air masses up from the Gulf of Mexico during the warm months of the year, producing a summer rainfall maximum. The prevailing northwesterly flow of Canadian air, during the winter, results in cold and relatively dry conditions. At intervals throughout the year, air masses from the Pacific Ocean move across the mountains to Iowa, producing comparatively mild and dry weather. Hot, dry winds, from the desert southwest, occasionally enter Iowa during the summer, resulting in unusually high temperatures and low humidities. As the surrounding terrain is low, there are no natural obstructions to the free sweep of air currents from all directions.

2.0312 Temperature. The average annual temperatures in Iowa range from 46F in the northern counties to 52F in the southeastern counties. The hottest month is July with an average daily maximum temperature of about 85F and a daily minimum in the lower sixties. January is the coldest month with daily maxima ranging from 24F to 34F, northern to southern counties, and the minima from 4F to 14F.

2.0313 Precipitation. Precipitation in Iowa ranges from 25 inches in the northwest to about 34 inches in the east and southeast with a state average of around 31 inches per year. The average annual snowfall varies from near 20 inches at Keokuk to as much as 45 inches over the northern counties. Drought occurs periodically in Iowa with the most severe cases of recent times occurring in the 1950's.

2.0314 Severe weather. Over 75 per cent of Iowa's 40 to 50 annual thunderstorms occur during the warmer half of the year. Occasionally they are accompanied by hail, high winds, heavy rains, and tornadoes. The probability of occurrence of thunderstorms is highest in late spring and early summer. Tornadoes occur most frequently in May and June in late afternoon and evening. Damaging hailstorms, reaching a maximum in early summer, average about 58 per year and destroy about one or 2 per cent of the major crops. The severe hailstorms occur more frequently over northwestern counties. Hail occurs, on the average, from two to six times a year, for any location. High winds at 15 feet reach 50 mph, sustained, in about half of the recorded years. Winds up to 75 mph, sustained, may be expected once in every 50 years at the 15 feet level[1].

2.0315 Dispersion Potential. The potential for atmospheric pollution buildup is dependent upon a number of meteorological factors, primarily, the mixed layer depth, wind speed within the mixed layer, and low level inversion frequency. These factors can impose impermeable boundaries and/or affect the rate that effluents are dispersed.

2.03151 Hosler (2) has tabulated the per cent frequencies of inversion and/or isothermal conditions, based below 500 feet above station elevation, for National Weather Service radiosonde stations in the contiguous United States. Data for a 10 year period were utilized for these computations. Interpolation between the stations allows estimation of inversion frequencies for the southeastern Iowa area. Table 2-5 presents estimates of inversion frequency obtained in the above manner.

2.03152 Takle et. al (3) have studied 6 years of data from a 32 meter tower located at Ames, Iowa and have presented monthly inversion frequencies which can be considered representative for most relatively flat rural areas in Iowa. These data have been averaged seasonally and annually and included in Table 2-5. General agreement exists between these data and the Hosler estimates. Differences may be due to smoothing and inaccuracies in interpolation of values derived from radiosonde data, problems with resolution of radiosonde data in the lowest 100 feet, and variability in average inversion duration for each occurrence.

2.03153 Due to the pronounced continental type climate of Iowa, inversion frequencies are closely related to the diurnal cycle; that is, there is a definite tendency for nocturnal stability and daytime instability at lower levels in the atmosphere.

2.03154 Holzworth (4) has supplemented the work of Hosler by estimating mean mixing depths and average wind speeds within the mixed layer, again, at National Weather Service radiosonde stations. The mixing depth is defined as the height above the surface at which an air parcel, when raised from the surface in a dry adiabatic manner, is at the same temperature as it's surroundings. Below this level relatively vigorous mixing occurs. Diffusion above this height is strongly inhibited due to thermal buoyancy considerations. Table 2-6 presents values of seasonal and annual morning and afternoon mixing depths and wind speeds for the southeastern Iowa region. The

Table 2-5

INVERSION FREQUENCIES IN IOWA

	Southeastern Area[a]		Central Area[b]	
	Per Cent of Total Hours	Average Days Per Period	Per Cent of Total Hours	Average Days Per Period
Winter[c]	37	58	18	57
Spring	30	64	25	76
Summer	30	74	34	90
Fall	38	59	35	81
Annual	34	240	28	304

---

[a] Inversions based below 500 feet; from (2)

[b] Inversions based below 105 feet; from (3)

[c] Winter is taken as Dec., Jan., and Feb.; Spring as Mar., Apr., and May; etc.

Table 2-6

MIXING DEPTHS AND LOW LEVEL WINDS IN SOUTHEASTERN IOWA*

	Morning		Afternoon	
	Mixing Depth feet	Wind Speed mph	Mixing Depth feet	Wind Speed mph
Winter	1300	14.5	1975	16.8
Spring	1575	15.7	4600	20.4
Summer	1150	11.0	5400	14.5
Fall	1300	12.3	3925	16.1
Annual	1300	13.4	3925	17.0

---

*From (4)

potential for air pollution buildup is greatest when the mixing depths and wind speeds are both low.

2.03155 The morning mixing depth values from Table 2-6, in general, reflect the morning breakup of the nocturnal inversion. The existence of low mixing depths and nocturnal inversions does not necessarily lead to pollutant buildups. Proper release heights need to be carefully considered; further details regarding this are included in the following section (2.0328).

2.032 Local Meteorology

2.0321 General. The Ottumwa plant site is in southeastern Iowa and, therefore, tends to have higher maximum and minimum temperatures and greater precipitation than elsewhere in the state. The plant site is within 10 miles of the two Ottumwa meteorological substations. One is inside the Ottumwa city limits and records mainly precipitation data, and one is outside the city at the Ottumwa municipal airport and is operated by the Federal Aviation Admininstration (FAA). This second substation records wind, precipitation, and temperature data. When information is needed that these two substations do not record, the data from other substations in the area or the first order station at Des Moines will be used. Des Moines is approximately 65 miles to the northeast of the plant site.

2.0322 Temperature. Temperatures for the Ottumwa site definitely reflect the strictly continental climate of the area as evidenced by their wide seasonal variance. Table 2-7 displays normals, means and extremes for the Des Moines area. The trends shown in the table hold for the Ottumwa area, although extremes can vary. For example, for the period 1950 to 1974 an extreme of 103F was recorded on July 27, 1956, for the site area and a low of -31F was recorded on January 14, 1957.

2.0323 Humidity. Like most states on the Great Plains, Iowa is a fairly humid area. As shown in Table 2-7 humidity is usually between 60 and 80 per cent, reaching its peak very early in the day and decreasing in value as the day progresses.

2.0324 Wind and storms. Figures 2-13 and 2-14 show annual wind distributions for Des Moines and Ottumwa, respectively. The major difference between the two figures is apparent; an observer bias against the reporting of wind directions from the NNE, ENE, ESE, etc. seems to exist at Ottumwa. The general patterns are similar, however, with a large portion of the winds from the southerly and northwesterly directions. The period of record for the Des Moines data, being longer and more recent than that for Ottumwa, is probably more representative of the actual conditions which exist over southeast

TABLE 2-7

NORMALS, MEANS, AND EXTREMES

Month	Temperature: Normal: Daily maximum	Temperature: Normal: Daily minimum	Temperature: Normal: Monthly	Temperature: Extremes #: Record highest	Year	Temperature: Extremes #: Record lowest	Year	Normal heating degree days (Base 65°)	Precipitation: Normal total	Precipitation: Maximum monthly	Year	Precipitation: Minimum monthly	Year	Precipitation: Maximum in 24 hrs.	Year	Snow, Ice pellets: Mean total	Snow, Ice pellets: Maximum monthly	Year	Snow, Ice pellets: Maximum in 24 hrs.	Year	Relative humidity: Hour 00 (Local time)	Hour 06	Hour 12	Hour 18	Wind &: Mean speed	Wind &: Prevailing direction	Wind &: Fastest mile: Speed	Fastest mile: Direction	Fastest mile: Year	Pct. of possible sunshine	Mean sky cover, sunrise to sunset	Mean number of days: Sunrise to sunset: Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Ice pellets 1.0 inch or more	Thunderstorms	Heavy fog	Temperatures: Max.: 90° and above $	Max.: 32° and below	Min.: 32° and below	Min.: 0° and below	Average daily solar radiation - langleys
(a)	(b)	(b)	(b)	10		10		(b)	(b)	31		31		31		31	31		31		9	9	9	9	21	19	20	20		20	21	21	21	21	31	31	31	21	9	9	9	9	
J	28.5	11.2	19.9	62	1967	-24	1970	1398	1.30	4.38	1960	0.07	1954	2.97	1960	8.1	19.0	1962	19.0	1942	78	80	72	73	11.7	NW	66	[illegible]	1959	51	6.7	8	6	17	7	2	0	2	0	20	30	9	
F	32.2	14.6	23.4	65	1967	-16	1962	1165	1.10	2.99	1951	0.13	1964+	1.77	1961	6.5	21.3	1962	12.1	1958	79	81	69	68	11.6	NW	56	[illegible]	1952	55	6.3	8	6	14	7	2	0	2	0	14	27	4	
M	42.9	24.6	33.8	83	1966+	-22	1962	967	2.09	5.37	1961	0.31	1956	2.42	1965	7.7	18.6	1960	8.9	1957	78	81	65	61	13.3	NW	60	[illegible]	1953	55	6.8	7	7	17	10	2	2	2	0	5	24	1	
A	59.4	38.0	48.7	90	1970	15	1970	489	2.53	6.11	1947	0.08	1962	2.05	1965	1.2	6.2	1959	6.2	1959	72	80	59	55	13.9	NW	76	[illegible]	1960	55	6.7	7	7	16	10	0	6	1	0	0	7	0	
M	71.4	49.8	60.6	98	1967	30	1967	211	4.07	7.53	1960	1.22	1949	2.79	1954	T	0.2	1966	0.2	1966	72	79	57	52	11.9	SE	70	[illegible]	1955	60	6.5	7	9	15	11	0	7	1	1	0	1	0	
J	81.3	60.7	71.0	99	1970	42	1969	39	4.71	14.19	1947	1.13	1963	5.80	1947	0.0	0.0		0.0		76	82	59	56	10.7	S	76	[illegible]	1955	66	6.0	7	11	12	11	0	10	1	3	0	0	0	
J	87.3	65.2	76.3	100	1966	48	1967	0	3.06	10.51	1958	0.42	1967	5.16	1958	0.0	0.0		0.0		77	82	58	57	9.1	S	73	[illegible]	1966	73	5.4	10	13	8	9	0	8	1	6	0	0	0	
A	84.7	63.4	74.1	100	1964	45	1967	9	3.67	10.47	1954	0.71	1953	3.26	1940	0.0	0.0		0.0		79	86	58	58	8.6	S	60	[illegible]	1960	72	5.3	11	10	10	9	0	7	1	5	0	0	0	
S	76.9	53.8	65.4	93	1961	32	1965	99	2.88	10.19	1961	0.41	1958	4.67	1961	T	T	1962	T	1942	81	86	62	62	9.8	S	55	[illegible]	1955	68	5.2	12	7	11	9	0	6	1	1	0	0	0	
O	65.7	42.6	54.2	93	1963	22	1969+	363	2.06	7.29	1941	0.03	1952	2.81	1967	0.1	2.4	1967	2.4	1967	71	78	54	56	10.8	S	56	[illegible]	1952	64	5.1	11	9	11	7	0	3	1	0	0	3	0	
N	46.5	27.6	37.1	76	1965+	-3	1964	837	1.76	4.60	1952	0.03	1969	3.35	1952	2.0	13.5	1966	11.6	1966	75	79	63	64	12.0	NW	72	[illegible]	1952	51	6.3	8	7	15	6	1	1	2	0	4	18	0	
D	33.5	17.0	25.3	66	1970	-16	1963	1231	1.14	2.90	1941	0.22	1946	1.24	1941	6.1	23.9	1961	11.0	1961	78	80	70	70	11.0	NW	61	[illegible]	1951	46	6.8	7	7	17	7	2	0	2	0	15	28	3	
YR	59.2	39.1	49.2	100	JUL. 1964+	-24	JAN. 1970	6808	30.37	14.19	JUN. 1947	0.03	NOV. 1969+	5.80	JUN. 1947	31.7	23.9	DEC. 1961	19.0	JAN. 1942	76	81	62	61	11.3	NW	76	[illegible]	APR. 1960+	60	6.1	104	97	164	105	10	50	16	18	58	140	17	

For period July 1961 through the current year.
Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows: Highest temperature 110 in July 1936 and earlier; lowest temperature -30 in January 1884; maximum monthly precipitation 15.79 in June 1881; maximum monthly snowfall 37.0 in January 1886.

(a) Length of record, years, based on January data. Other months may be for more or fewer years if there have been breaks in the record.
(b) Climatological standard normals (1931-1960).
* Less than one half.
+ Also on earlier dates, months, or years.
T Trace, an amount too small to measure.
Below zero temperatures are preceded by a minus sign.
The prevailing direction for wind in the Normals, Means, and Extremes table is from records through 1963.
$ ≥ 70° at Alaskan stations.

Unless otherwise indicated, dimensional units used in this bulletin are: temperature in degrees F.; precipitation, including snowfall, in inches; wind movement in miles per hour; and relative humidity in percent. Heating degree day totals are the sums of negative departures of average daily temperatures from 65° F. Cooling degree day totals are the sums of positive departures of average daily temperatures from 65° F. Sleet was included in snowfall totals beginning with July 1948. The term "ice pellets" includes solid grains of ice (sleet) and particles consisting of snow pellets encased in a thin layer of ice. Heavy fog reduces visibility to 1/4 mile or less.

Sky cover is expressed in a range of 0 for no clouds or obscuring phenomena to 10 for complete sky cover. The number of clear days is based on average cloudiness 0-3, partly cloudy days 4-7, and cloudy days 8-10 tenths.

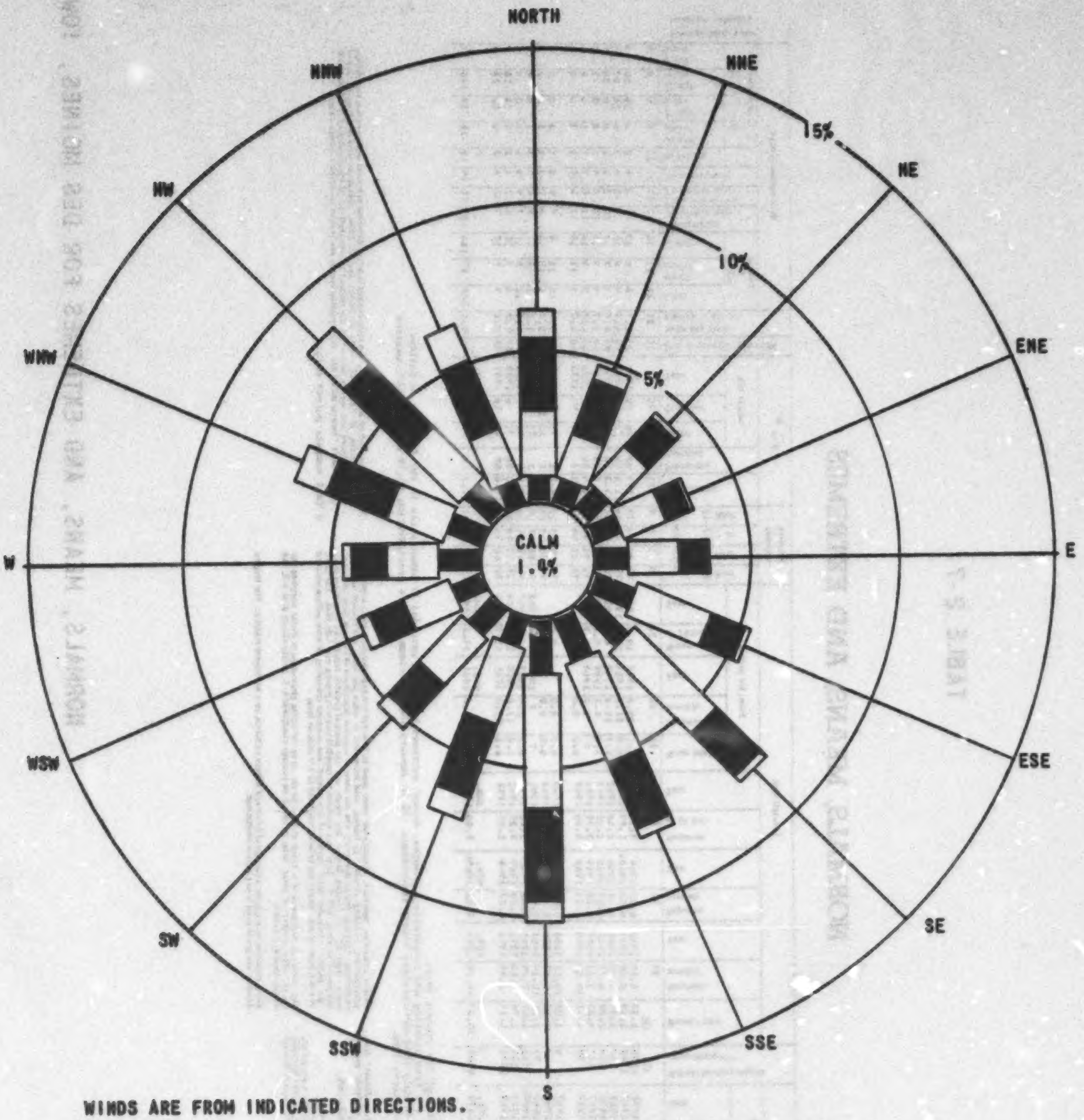
Solar radiation data are the averages of direct and diffuse radiation on a horizontal surface. The langley denotes one gram calorie per square centimeter.

& Figures instead of letters in a direction column indicate direction in tens of degrees from true North; i.e., 09 - East, 18 - South, 27 - West, 36 - North, and 00 - Calm. Resultant wind is the vector sum of wind directions and speeds divided by the number of observations. If figures appear in the direction column under "Fastest mile" the corresponding speeds are fastest observed 1-minute values.

To 8 compass points only.

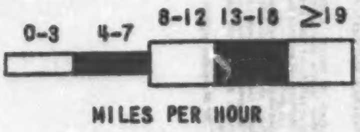
NORMALS, MEANS, AND EXTREMES FOR DES MOINES, IOWA

FIGURE 2-13



WINDS ARE FROM INDICATED DIRECTIONS.
PERIOD OF RECORD: 1951 THROUGH 1960

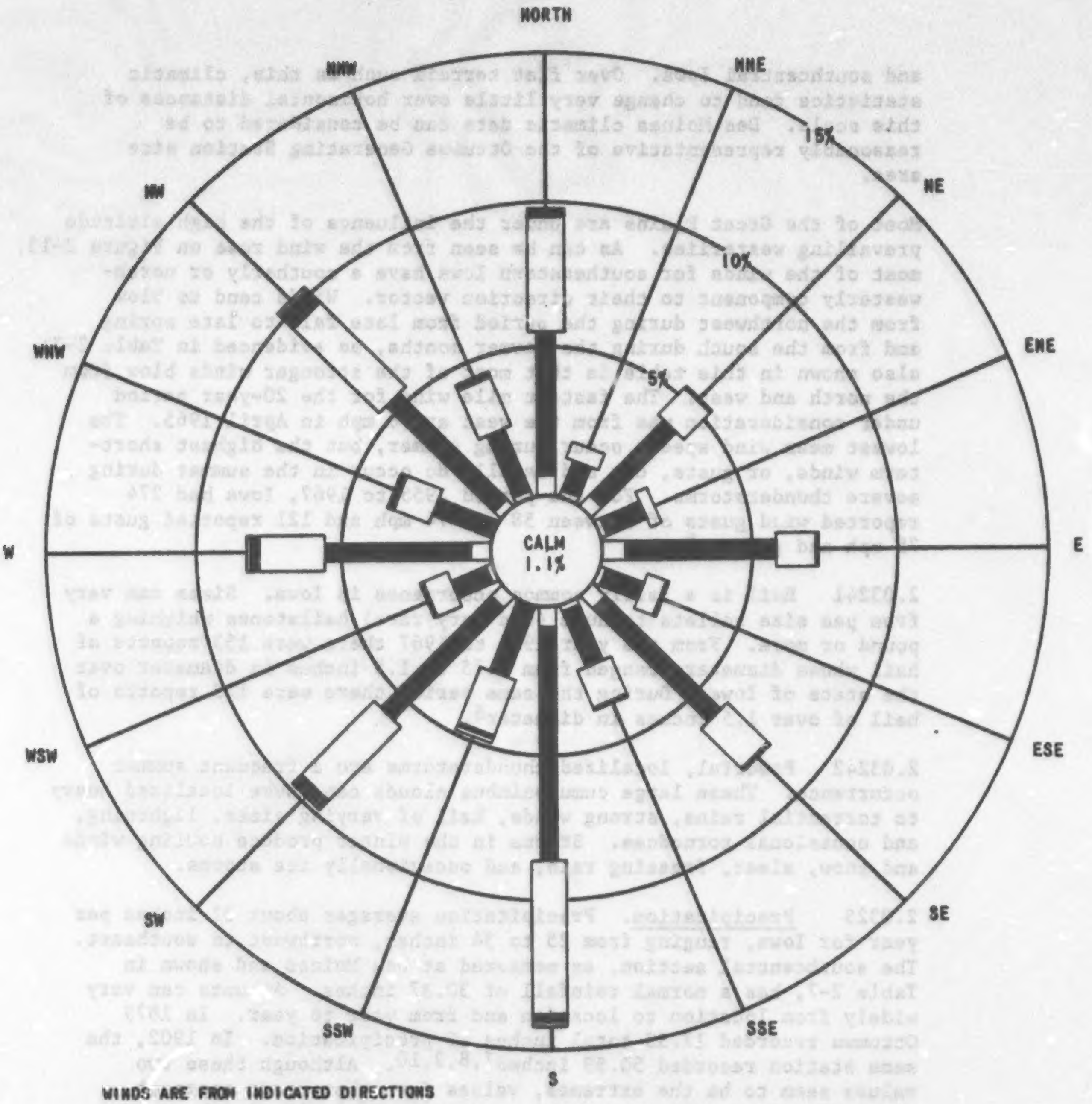
ANNUAL WIND ROSE
DES MOINES, IOWA



MILES PER HOUR

REFERENCE:
WEATHER BUREAU, DECENNIAL CENSUS OF THE UNITED STATES CLIMATE - SUMMARY OF HOURLY OBSERVATIONS, 1951-1960, UNITED STATES DEPARTMENT OF COMMERCE, DES MOINES, IOWA

FIGURE 2-14



WINDS ARE FROM INDICATED DIRECTIONS

PERIOD OF RECORD: 1943 THROUGH 1945

ANNUAL WIND ROSE
OTTUMWA, IOWA

REFERENCE:

NATIONAL CLIMATIC CENTER, FEDERAL BUILDING, ASHEVILLE, N.C.
(UNPUBLISHED SUMMARY)

and southcentral Iowa. Over flat terrain such as this, climatic statistics tend to change very little over horizontal distances of this scale. Des Moines climatic data can be considered to be reasonably representative of the Ottumwa Generating Station site area.

Most of the Great Plains are under the influence of the high altitude prevailing westerlies. As can be seen from the wind rose on Figure 2-13, most of the winds for southeastern Iowa have a southerly or northwesterly component to their direction vector. Winds tend to blow from the northwest during the period from late fall to late spring and from the south during the warmer months, as evidenced in Table 2-7; also shown in this table is that most of the stronger winds blow from the north and west. The fastest mile wind for the 20-year period under consideration was from the west at 76 mph in April 1965. The lowest mean wind speeds occur during summer, but the highest short-term winds, or gusts, can and usually do occur in the summer during severe thunderstorms. For the period 1955 to 1967, Iowa had 274 reported wind gusts of between 58 and 74 mph and 121 reported gusts of 75 mph and greater[5].

2.03241 Hail is a fairly common occurrence in Iowa. Sizes can vary from pea size pellets to huge (and very rare) hailstones weighing a pound or more. From the year 1956 to 1967 there were 153 reports of hail whose diameters ranged from 0.75 to 1.5 inches in diameter over the state of Iowa. During the same period there were 123 reports of hail of over 1.5 inches in diameter[6].

2.03242 Powerful, localized thunderstorms are a frequent summer occurrence. These large cumulonimbus clouds can cause localized heavy to torrential rains, strong winds, hail of varying sizes, lightning, and occasional tornadoes. Storms in the winter produce howling winds and snow, sleet, freezing rain, and occasionally ice storms.

2.0325 Precipitation. Precipitation averages about 31 inches per year for Iowa, ranging from 25 to 34 inches, northwest to southeast. The southcentral section, as measured at Des Moines and shown in Table 2-7, has a normal rainfall of 30.37 inches. Amounts can vary widely from location to location and from year to year. In 1879 Ottumwa recorded 17.33 total inches of precipitation. In 1902, the same station recorded 50.59 inches[7,8,9,10]. Although these two values seem to be the extremes, values for other years approach them. Nearly two-thirds of the annual precipitation is measured from April through September, with rain occuring about 100 days per year. Snowfall averages about 20 inches in the southern portions of Iowa. The average date for the first one-inch snowfall is December 10 in the southeast portion of the state, with the first trace of snow falling about a month earlier. The possibility of snow for the season is usually over by April, but can extend into May.

2.0326 Fog. Weather data recorded at Des Moines for the period 1951-1960 indicates a fairly low occurrence of heavy fog. For the 10-year period, there was an average of 19 days per year of visibility of 2.5 miles or less, and an average of 6 days per year of visibility of less than three quarters of a mile[11].

2.0327 Tornadoes. Although tornadoes are fairly common in Iowa, the chances of any one small area being struck are relatively slim. Figure 2-15 shows a 10,000 square mile area centered around the plant site. Drawn onto this map are all of the reported tornado sitings and paths for the year 1953 to 1973 as recorded by the National Severe Storms Forecast Center in Kansas City, Missouri. There have been 88 tornadoes reported within this area, but only 6 have been reported within 20 miles of the site[12].

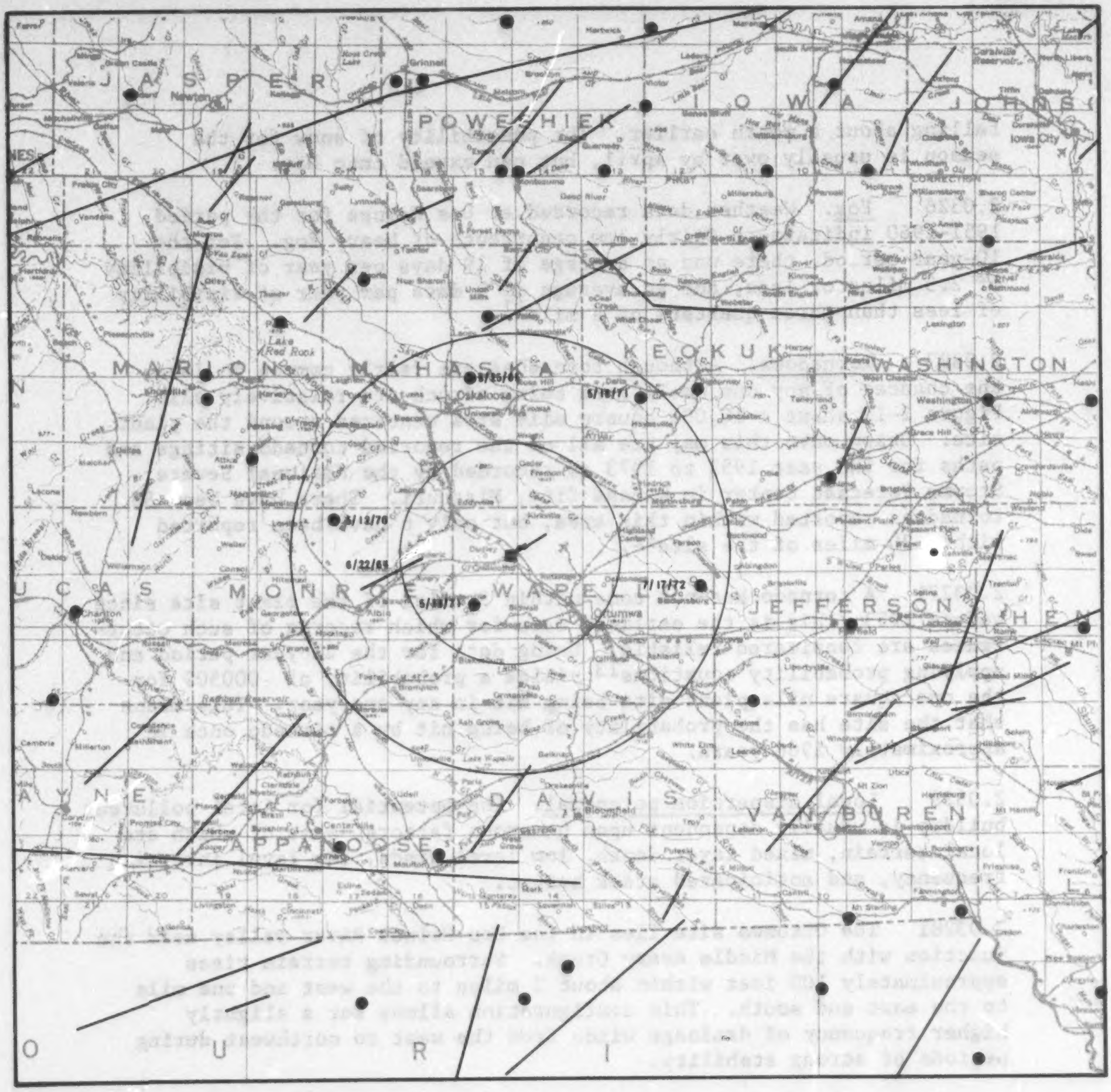
2.03271 A tornado has not come within 5 miles of the plant site since before 1953; this is the earliest date for which records of such occurrences are considered reliable. Using data for the 21-year period and applying probability equations[13] yields a probability of .000509 for the one square mile plant site being hit in any one year. This means that the site has the probability of being hit by a tornado once in approximately 1966 years.

2.0328 Local dispersion potential. The potential for local pollutant buildup is usually dependent upon numerous factors, some of which are local terrain, mixed layer depth, low level winds, low level inversion frequency, and anticipated stack height.

2.03281 The Ottumwa site lies in the Des Moines River valley near the junction with the Middle Avery Creek. Surrounding terrain rises approximately 100 feet within about 2 miles to the west and one mile to the east and south. This configuration allows for a slightly higher frequency of drainage winds from the west to northwest during periods of strong stability.

2.03282 Local inversion frequencies, low level winds, and terrain considerations are not expected to be factors of great importance at the Ottumwa site if a stack of adequate height is incorporated into the design. A stack height of 600 feet has been assumed for dispersion calculations made in Section 4.022 of this report. Utilizing a worst case analysis with regard to emission rates, low level wind speeds and atmospheric turbulence (stability), it has been determined that ground level concentrations will not surpass the most stringent applicable ambient air quality standards.

FIGURE 2-15



TORNADO PATH

● TORNADO SITING

SCALE 1" = 14.2 MILES

TORNADO OCCURRENCES IN
SITE VICINITY FROM 1953 TO 1973

2.03283 The calculations referred to in the previous paragraph dealt with what might be called "normal" meteorological conditions. This is where the plume spreads in an unrestricted fashion both vertically and horizontally, except for the impermeable boundary represented by the ground. Conditions other than this occur during morning inversion breakup and with plume trapping beneath elevated inversion layers produced by stagnant high pressure areas. The number of days per year of stagnant conditions has been found to be very nearly zero for southeastern Iowa[14]. Morning inversion breakup can allow relatively high ground level concentrations for very short time periods (less than 30 minutes); however, these conditions are not expected to cause averages over longer time periods to exceed applicable standards.

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2.04 Economic and Social Factors

2.041 Introduction. The objectives of the economic and social portions of this report are to describe the region in which the proposed plant will be located, and to assess the impacts of the construction and operation of the Ottumwa Generating Station (OGS) on local economic and social activities. The purpose of this section is to accomplish the former objective and to lay the groundwork for accomplishing the latter by developing a base line ("without OGS") projection of selected economic and social variables from which impacts on these variables can be measured. These expected future values are developed through the use of both quantitative and qualitative analyses. Any impacts that OGS might have on future local economic and social activity are evaluated in subsequent sections of this report.

2.0411 Study areas. Four study areas have been defined for purposes of analyzing social and economic effects. County boundaries were used in establishing areas, primarily for expediency in gathering data but also to reflect the appropriate degree of accuracy with which impacts may be assigned to a geographic area. It should be emphasized that economic and social effects of OGS will not disperse uniformly in all directions and are unlikely to reach every small community and farmstead. The following study areas were chosen because selected OGS impacts will reliably occur within their boundaries.

2.04111 Station site. The actual Station Site consists of approximately 795 acres in Wapello County some 8 miles northwest of Ottumwa, Iowa on the west bank of the Des Moines River.

2.04112 Primary area. The Primary Area consists of Wapello, Mahaska, and Monroe Counties, Iowa.

2.04113 Secondary area. The Secondary Area includes the entire 28-county Iowa Southern Utilities service area outside the Primary Area.

2.04114 External area. All area beyond the Secondary Area is defined as the External Area. No quantification of External Area economic or social factors will be attempted, although benefits from material purchases and multiplier effects will occur.

2.0412 Projection methodology. In order to measure OGS-related impacts on economic activity in the Primary Area, projections of certain socio-economic variables were made for "with OGS' and "without OGS" levels of economic activity. These projections were developed through the use of an econometric model of the Primary Area, which was derived from historical relationships exhibited by these variables. Only the projections themselves are discussed in the body of this report. For further explanation and interpretation of the econometric model and its results refer to Appendix F. The balance of this section pertains to historical data and "without OGS" projections. Subsection 4.0119 discusses "with OGS" projections and OGS-related socioeconomic impacts.

2.042 Economic Setting. The objectives of this section are to describe the existing status of certain economic variables in the Station Site and Primary Area, and to project development of these same variables in the Primary Area without OGS. Table 2-8 lists the the impact areas and the economic variables which are evaluated in each impact area. The bases for choosing and discussing variables are generally accepted economic theories and historical experience concerning construction and operation of large electric energy generating stations.

2.0421 Population and population density. Population of the Primary Area[1,2,3,4] has declined steadily since 1950, both in actual numbers and as a percentage of total Iowa population. Population density in the Primary Area has also declined some 16 per cent since 1950, while population density in the State of Iowa has increased about 10 per cent during the same period (See Appendix G, Table G-1). Population density (population per square mile) for each county in the Primary Area was used in lieu of total population in order to eliminate the effects of variances in county sizes. Population projections with OGS were derived from the Iowa Development Commission's county estimates[5]. These projections, shown in Table 2-9, amount to a .46 per cent compound annual growth rate over the 35-year period from 1975 to 2010.

2.0422 Labor force and employment characteristics. Section 2.0422 discusses historical and projected "without-OGS" levels of total labor force, employment, unemployment rate, and the real wage rate in the Primary Area.

2.04221 Total labor force. Total labor force data includes employed persons and those without jobs who consider themselves part of the labor force. The data shown in Table 2-9 indicates that the total labor force has decreased during the 25 year historical study period and has maintained a nearly constant relationship with total population. Projections of the total labor force are also presented in Table 2-9. As in the case of population, the total labor force is expected to increase.

2.04222 Employment/unemployment rate. Historical employment data in the Primary Area[6] is shown in Table 2-9 along with the unemployment

Table 2-8

ECONOMIC VARIABLES CONSIDERED BY GEOGRAPHIC AREAS

Station Site	Primary Region	Secondary Area
Public Facilities	Population	Ad Valorem Taxes
Public Services	Population Density (No./Sq. Mi.)	
Ad Valorem Tax Revenues	Total Labor Force	
Cropland Removed from Production	Employment	
	Unemployment Rate	
	Personal Income	
	Wages and Salaries	
	Property and Proprietor Income	
	Real Wage Rate	
	Land in Farms	
	Number of Farms	
	Average Size of Farms	
	Value of Farmland Land and Buildings	
	Farm Income	
	Retail Sales	
	Business Index	

Table 2-9

PRIMARY AREA

HISTORICAL ECONOMIC DATA AND PROJECTED ECONOMIC ACTIVITY WITHOUT OGS

Year	Population(a) #	Population Density(a) #/SQ MI	Total Labor Force(b) #	Employment(b) #	Unemployment Rate(b) %	Real Wage Rate(c) $/HR	Personal Income(b) $1,000	Wages and Salaries(b) $1,000
1950	89,500	62.0	31,919	30,609	4.1	1.26	223,646	77,144
1955	81,700	56.6	31,670	30,366	4.1	2.05	258,779	134,493
1960	80,200	55.5	31,651	30,387	4.0	2.66	302,748	161,477
1965	79,200	54.8	30,171	29,138	3.5	3.40	373,575	198,037
1970	72,100	49.9	29,910	28,370	5.1	3.63	399,114	205,768
1974	75,000	51.9	28,980	28,270	5.7	3.84	437,527	216,982
1975	76,774	53.2	31,222	29,849	4.4	4.08	464,412	243,836
1976	77,148	53.4	31,798	30,412	4.4	4.06	470,665	246,793
1977	77,521	53.7	32,374	30,975	4.3	4.03	476,917	249,750
1978	77,895	53.9	32,950	31,538	4.3	4.01	483,170	252,707
1975	78,268	54.2	33,527	32,102	4.3	3.98	489,422	255,664
1980	78,642	54.5	34,103	32,665	4.2	3.96	495,675	258,622
1981	79,015	54.7	34,679	33,228	4.2	3.94	501,927	261,579
1985	80,510	55.8	36,984	35,401	4.1	3.85	526,937	273,407
1990	82,378	57.0	39,065	38,298	3.9	3.76	558,199	288,193
1995	84,245	58.3	42,746	41,114	3.8	3.68	589,461	302,979
2000	86,113	59.6	45,627	43,930	3.7	3.62	620,723	317,765
2005	87,981	60.9	48,508	46,746	3.6	3.56	651,985	332,551
2010	89,849	62.2	51,390	49,563	3.6	3.50	683,246	347,337

Year	Profit and Proprietor Income(b) $1,000	Disposable Income(b)	Transfer Payments(b) $1,000	Contributions to Special Insurance(b) $1,000	Farm Income(b) $1,000	Land in Farms(d) Acres	Number of Farms(d) #	Average Size of Farms(d) Acres/Farm
1950	129,253	198,131	19,646	2,397	44,849	893,660	5,938	150
1955	118,105	232,081	18,792	2,611	30,407	895,302	5,593	160
1960	121,606	274,982	24,868	5,173	30,539	896,219	5,270	170
1965	148,609	342,002	35,895	8,966	40,807	882,757	4,411	200
1970	151,186	366,606	55,084	12,523	31,943	835,125	3,721	224
1974	175,209	395,870	61,088	15,752	33,105	833,580	3,695	226
1975	175,285	425,041	61,888	16,597	39,417	835,206	3,604	231.7
1976	177,196	431,909	63,947	17,272	39,762	832,360	3,515	236.8
1977	179,107	437,777	66,006	17,946	40,108	829,514	3,426	242.1
1978	181,018	443,646	68,065	18,621	40,453	826,668	3,339	247.6
1979	182,929	449,514	70,124	19,295	40,798	823,822	3,252	253.3
1980	184,840	455,382	72,183	19,970	41,144	820,976	3,167	259.2
1981	186,751	461,250	74,242	20,645	41,489	818,130	3,082	265.4
1985	194,395	484,724	82,478	23,343	42,871	806,746	2,753	293.0
1990	203,950	514,066	92,722	26,716	44,597	792,517	2,358	336.1
1995	213,504	543,408	103,067	30,089	46,324	778,287	1,977	393.7
2000	223,059	572,749	113,361	33,462	48,051	764,057	1,606	475.4
2005	232,614	602,091	123,656	36,835	49,778	749,827	1,244	602.8
2010	242,168	631,432	133,950	40,208	51,505	735,597	888	828.4

Sources:
(a) Sales Management Magazine, Annual Survey of Business Issues, 1949-74.
(b) Bureau of Economic Analysis, Regional Economic Information System, Department of Commerce.
(c) Calculated from deflated wage and salaries, employment and 2,000 hour annual average per employee.
(d) Iowa Department of A riculture, Iowa Crop and Livestock Reporting Service.

Table 2-9 (Continued)

Year	Real Estate Value Per Sq. Mile $1,000/mi²	Personal & Public Service Valuation (e) $1,000	State Sales Taxes (f) $1,000	Federal Income Taxes (i) $1,000	State Income Taxes (i) $1,000
1950	52.08	25,607	3,786	23,790	1,725
1955	57.82	34,301	4,190	24,363	1,946
1960	63.53	39,530	3,872	25,866	1,900
1965	67.91	42,322	4,115	28,636	2,937
1970	78.90	36,266	6,348	29,533	3,975
1974	89.36	36,866	6,293	32,098	5,559
1975	92.5	39,080	6,432	32,290	6,082
1976	95.9	38,923	6,546	32,538	6,218
1977	99.3	38,739	6,657	32,786	6,354
1978	102.9	38,526	6,770	33,034	6,490
1979	106.6	38,285	6,883	33,282	6,626
1980	110.5	38,014	6,996	33,530	6,763
1981	114.6	37,712	7,109	33,778	6,899
1985	132.4	36,165	7,560	34,770	7,443
1990	159.0	33,375	8,125	36,009	8,124
1995	191.3	29,448	8,689	37,249	8,804
2000	230.4	24,151	9,254	38,489	9,485
2005	277.8	17,201	9,818	39,729	10,165
2010	335.2	8,255	10,382	40,969	10,846

Year	Assessed Value of Farm Land & Buildings (e) $1,000	Avg. Assessed Value of Farm Land & Buildings (e) $/Acre	Retail Sales (f) $1,000	Business Index (g)	Bank Deposit (h) $1,000	Assessed Property Valuation (e) $1,000	Real Estate Valuation (e) $1,000
1950	25,016	27.99	196,808	80.5	126,405	100,809	75,201
1955	33,805	37.85	201,433	86.6	123,846	117,793	83,491
1960	38,387	42.83	206,696	84.3	127,244	131,269	91,738
1965	42,168	47.77	212,124	101.3	170,751	140,385	98,062
1970	53,408	64.05.	222,463	99.7	221,117	150,199	113,934
1974	53,565	70.26	234,071	130.9	286,647	165,897	129,030
1975	56,229	67.3	237,961	133.4	304,441	172,702	133,622
1976	58,047	70.7	239,038	135.2	310,670	177,336	138,413
1977	59,875	72.2	240,114	137.0	316,899	182,137	143,399
1978	60,904	73.7	241,191	138.8	323,128	187,112	148,586
1979	61,932	75.2	242,268	140.6	329,357	192,268	153,982
1980	62,960	76.7	243,342	142.4	335,586	197,610	159,396
1981	63,908	78.2	244,422	144.2	341,815	203,146	165,434
1985	68,101	84.4	248,730	151.4	366,731	227,382	191,217
1990	73,241	92.4	254,114	160.4	397,876	263,013	229,638
1995	78,382	100.7	259,499	169.4	429,022	305,706	276,258
2000	83,523	109.3	264,883	178.4	460,167	356,917	332,766
2005	88,663	118.2	270,268	187.4	491,312	418,409	401,208
2010	93,804	127.5	275,653	196.4	522,457	492,307	484,052

Sources:
(e) Iowa Department of Revenue, Research and Statistics Division, Personal Correspondence J. Hibbs, May 28, 1975, annual value 1950-1974.
(f) Iowa Department of Revenue, Retail Sales and Use Tax, 1950-1974.
(g) Business Conditions Digest, Services 811, Composite index of 12 leading indicators.
(h) Federal Reserve Bank of Chicago.
(i) Iowa Department of Revenue, Personal Correspondence.

rate derived from total labor force and unemployment[6]. Total employment in the Primary Area has decreased over the historical study period, 1950 to 1975. As a result of the projected decreases in the total labor force and expected increases in employment, the unemployment level is expected to decrease.

2.04223 Real wage rate. The real wage rate is defined as total deflated wages and salaries (in 1981 dollars) divided by total employment expressed in man-hours. It is assumed that each man-year of employment is equivalent to 2000 man-hours. Substantial increases in the real wage rate over the 25-year study period are explained by greater increases in wages and salaries than in hours of employment, given the above productivity assumption (2000 man-hours/year). Projected real wage rate levels without OGS are calculated from projected wages and salaries and employment. As shown in Table 2-9, increases in the real wage rate indicate real increases in earning power (the effects of inflation having been removed).

2.0423 Income levels. Subsection 2.0423 contains historical and "without-OGS" projections of personal income, disposable income, wages and salaries, profit and proprietor income, transfer payments, personal contributions to social insurance, and farm income.

2.04231 Personal income. Historical personal income in the Primary Area[7], as shown in Table 2-9, is defined as wage and salary disbursements, other labor income, profit and proprietor income, and transfer payments less personal contributions for social insurance. The historical personal income series in Table 2-8 is derived from Bureau of Economic Analysis data[7] and deflated to 1981 dollars. The derivation of the 1981 series price deflators is explained in Appendix F. Real personal income has grown at a compound annual rate of approximately 3 per cent during the 25-year historical study period, while real personal income per capita has grown at slightly more than 3.5 per cent. Historically, income per capita in the Primary Area has been slightly below the state-wide level (see Appendix G, Table G-1). The personal income (PY) projections shown in Table 2-9 are derived using projections of their components in the following identity.

$PY = WS + PRY + TR - SI$

Projected levels of these components--wages and salaries (WS), profit and proprietor income (PRY), and transfer payments (TR) less contributions for social insurance (SI)--are discussed in the following sections.

a. Wages and salaries. Historical wage and salary payments in the Primary Area[7], as shown in Table 2-9, include income paid to labor including employee bonuses, commissions, payments in kind, and tips. These data, a major component of personal income, are highly correlated to employment levels and reflect variations in activity of both export and residentiary base industries. Historical wage and salary payments have grown at a compound rate slightly greater than 4 per cent from 1950 to 1974. Wages and salaries have constituted a steadily increasing share of total personal income in the Primary Area. In 1974, wage and salary payments represented about 53 per cent of personal income. Estimated future wage and salary payments shown in Table 2-9 are expected to continue to constitute one-half or more of total personal income. This relationship may be interpreted as maintenance of the current real income distribution and constitutes a desirable balance among income earning groups in the Primary Area.

b. Profit and proprietor income. Historical Primary Area profit or property income[7] consists of dividends, interest, and net rents accruing to persons. Proprietor income is the income derived from unincorporated enterprises such as proprietorships, partnerships, and producer's cooperatives. The sum of these two variables is presented in Table 2-9. This total, in terms of constant 1981 dollars, has grown at a compound annual rate slightly greater than one per cent over the historical study period. Projected Profit and Proprietor Income, excluding any effects of OGS, is presented in Table 2-9. The values shown are expressed in constant 1981 dollars so that fluctuations due to price changes in the economy have been eliminated and the projected levels reflect real increases and decreases. It is expected that Profit and Proprietor Income will increase over time.

c. Transfer payments and contributions to social insurance. Historical transfer payments in the Primary Area[7], as shown in Table 2-9, constitute a gradually increasing share of total personal income. Deflated transfer payments, defined as income paid to residents by federal and state agencies for which no goods or services are currently received in return, represented 13 per cent of total personal income in 1974. The historical relationship between transfer payments and personal income is expected to remain stable over time. Personal contributions to social insurance[7], as shown in Table 2-9, are subtracted from other income sources to obtain total personal income. Social insurance contributions are determined by personal income, up to a certain level, and constitute an increasing share to be subtracted from personal income. These contributions totalled about 3.5 per cent of personal income in 1974. Projected personal contributions to social insurance are shown in Table 2-9.

2.04232 Farm income. Farm Income[7] is composed of farm proprietors income and farm wages and salaries. These data include government payments to farmers under soil conservation, price guarantees and subsidies, and other government programs. Historical and projected levels of farm income appear in Table 2-9. Projected values of this variable were derived from sources outside the econometric model of the Primary Area.

2.0424 Agricultural land use. This subsection contains historical and "without-OGS" projections of land in farms, number of farms, average size of farms, value of farmland and buildings, and average value of farmland and buildings.

2.04241 Land in farms, number of farms, and average size of farms. Historical data concerning this portion of the farm sector in the Primary Area is shown in Table 2-9. Land in farms and total number of farms have been decreasing during the study period[8]. This trend is consistent with historical state-wide experience. Average size of farms in number of acres, defined as land in farms divided by number of farms, has been increasing, which is also consistent with the Iowa state trend. Projected levels of these variables without OGS are shown in Table 2-9. Past trends in these three variables are expected to continue. These trends, along with projected increases in farm income, suggest more intensive use of farmland as the amount of farmland increases.

2.04242 Value and average value of farmland and buildings. Value of farmland and buildings is determined by the demand for land and buildings, which in turn depends upon the productivity of the land, population density, and anticipated future economic conditions. The average value of farmland and buildings is simply the assessed value divided by the acreage in farms. Data for the historical and projected assessed valuation of farmland and buildings[9] and average assessed valuation per acre are presented in Table 2-9. The data shown for these two variables are in current dollars (not constant 1981 dollars). During the 25-year historical study period the assessed valuation of farmland and buildings has grown at a compound rate of about 3.5 per cent while the average value per acre increased at an approximate rate of 3.75 per cent. The upward trend in assessed valuation of farmland and buildings is expected to continue through both the construction and operation phases of OGS.

2.0425 Industrial and business activity. This subsection contains historical data and "without-OGS" projections of retail sales, the business index, and bank deposits.

2.04251 Retail sales. Historical and projected retail sales are presented in Table 2-9. The data shown are for net taxable retail sales (i.e., the dollar volume of nonexempt goods and services sold each year) and are expressed in constant 1981 dollars. Historically, retail sales have grown at approximately a one per cent compound annual rate since 1950. It is expected that growth consistent with past trends will be experienced in future levels of this variable.

2.04252 Business index. The U.S. business index[12], as shown in Table 2-9, is Series 811 from Business Conditions Digest. This series is a composite of 12 leading indicators in the U.S. economy before reverse trend adjustment. This variable was projected by linear time-series regression. Projected levels of the business index appear in Table 2-9.

2.04253 Bank deposits. Historical deflated bank deposits in the Primary Area[13], as shown in Table 2-9, have grown at a 3.25 compound annual rate over the historical period, 1950-1974. Bank deposits, which are indicators of local business activities, depend on disposable income (personal income after taxes) and the business index. Projected bank deposits are also presented in Table 2-9. Continued growth is anticipated, but at a rate slightly lower than in the past.

2.0426 Real estate sector. This section contains data concerning historical and projected total assessed property valuation, real estate valuation, real estate valuation per square mile, and personal and public service property valuation.

2.04261 Total assessed property valuation. Historical levels of assessed property valuation[9] in the Primary Area appear in Table 2-9. These historical levels were calculated by summing historical real estate valuation and personal and public service valuation. These assessed property valuation data were not converted to 1981 dollars since property valuations are not subject to annual price fluctuations in the same manner as other monetary variables. Projected levels of assessed property valuation, shown in Table 2-9, were estimated from their historical relationship with real estate valuation and time. Since 1950 the assessed property valuation in the Primary Area has grown at a compound annual rate of approximately 2 per cent. It is expected that without OGS similar growth trends will be experienced in future years.

2.04262 Real estate valuation and valuation per square mile. Historical real estate valuation in the Primary Area[9] generally constitutes the greater part of total assessed property valuation as shown in Table 2-9. Real estate valuation per square mile is calculated by dividing real estate valuation in each county by number of square miles and is employed in order to eliminate the effects of variation in the size of counties, thereby allowing comparison of valuations among counties in the Primary Area. Projected levels of real estate valuation derived from projected real estate valuation per square mile are also shown in Table 2-9. Historical real estate valuation has grown at an approximate compound annual rate of 2 per cent. Projected levels of this variable indicate a pattern of growth similar to that experienced during the 25-year historical study period.

2.04263 Personal and public service property valuation. Historical levels of personal and public service property valuation[9], as shown in Table 2-9, are the second and generally smaller component of total assessed property valuation. This variable includes tangible individual personal property, business and professional personal property, and utility property assessed by the Iowa State Department of Revenue. Projected levels of personal and public service property valuation without OGS are calculated directly by subtracting real estate value from total property value. Personal and public service property valuation projections appear in Table 2-9.

2.0427 Government revenues. This subsection discusses historical and projected "without-OGS" levels of state retail sales tax revenues, federal income tax revenues, and state personal income tax revenues.

2.04271 Retail sales taxes. Historical deflated retail sales tax revenues[14], as shown in Table 2-9, are the dollar volume collected by the State of Iowa through retail sales tax collections. These data are aggregated to correspond to the three-county Primary Area and have grown at a slightly higher rate than taxable retail sales due to periodic increases in the rate of taxation during the historical study period. Projected retail sales tax revenues which appear in Table 2-9 are based on their estimated relationship to retail sales and time. Future levels of retail sales taxes are projected to increase in a manner consistent with historical trends.

2.04272 Federal and state income taxes. Historical federal and state income tax revenues collected in the Primary Area[9] are shown in Table 2-9. The Primary Area has provided an average of 2.57 per cent of total Iowa State income tax collections from 1950 to 1974.

2.043 Community Profile/Public Facilities and Services. The objectives of this section are identical to that of section 2.042, i.e. to describe the existing status of the area and project development in the area without OGS. This section, however, deals primarily with demographic factors which lend themselves to qualitative rather than quantitative analysis. Recent values for these factors can be found in Table 2-10. Indicators of the ability of the study areas to support growth are also considered in this section.

2.0431 Primary area. The character of the Primary Area is determined in this subsection through examination of population migration and composition, and population and income distribution. Public facilities and services considered include housing water and sewer capacities.

2.04311 Population in the three county (Mahaska, Monroe and Wapello) Primary Area declined approximately 8 per cent in the decade 1960 to 1970. This trend is opposite to that observed in Iowa and the

Table 2-10

SELECTED STATISTICS FOR VICINITY OF OGS

	Units	United States	Iowa	Primary* Area	Wapello County	City of Ottumwa
Population						
Total 1970	ea.	203,212,877	2,824,376	73,683	42,149	29,695
Change 1960-1970	%	13.3	2.5	(8.1)	(8.6)	(12.6)
Net Migration 1960-1970	%	1.7	(6.7)	(12.1)	(13.8)	out
Composition						
Sex - % female, 1970	%	51.3	51.4	52.2	52.7	53.7
Race - % caucasion, 1970	%	87.6	98.6	99.3	99.2	98.9
Age - 1970						
less than 5 years	%	8.4	8.2	7.1	7.1	7.1
5 through 17 years	%	26.0	26.5	24.7	25.4	24.5
18 through 64 years	%	55.7	52.9	52.6	52.9	53.2
65 years or more	%	9.9	12.4	15.6	14.6	15.2
Median age	yrs.	28.3	29.1	34.5	34.0	34.5
Education - 1970						
Population 25 yrs of age or more	ea.	109,899,359	1,540,588	43,498	24,787	17,594
Years of school completed						
less than 5 years	%	5.5	1.9	2.2	2.2	2.2
4 years of H.S. or more	%	52.3	59.0	50.9	50.6	51.8
4 years college or more	%	10.7	9.1	6.2	5.8	6.6
Median education	yrs.	12.1	12.2	12.0	12.0	12.1
Distribution						
Urban - 1970	%	73.5	57.2	61.2	70.5	100.0
Rural - 1970						
Farm	%	22.4	24.6	17.6	9.4	N.A.
Non-farm	%	4.1	18.2	21.2	20.1	N.A.
Income						
Families	ea.	51,168,599	717,776	19,776	11,241	7,939
Families with income:						
less than $3,000	%	10.3	10.1	14.0	11.9	11.1
$3,000 - $4,999	%	10.0	10.8	12.4	11.1	11.7
$5,000 - $6,999	%	11.9	13.4	14.4	13.6	13.3
$7,000 - $9,999	%	20.6	22.9	24.9	26.2	25.5
$10,000 - $14,999	%	26.6	26.6	23.5	25.7	26.5
$15,000 - $24,999	%	16.0	12.8	8.5	9.3	9.5
$25,000 or more	%	4.6	3.4	2.3	2.2	2.4
Median income	$	9,586	9,016	8,045	8,501	8,648
Below low income level	%	10.7	8.9	11.8	9.8	9.3
Housing						
Total year-round units - 1970	ea.	67,699,084	954,975	27,003	15,393	11,165
Change 1960 - 1970	%	19.9	7.4	(1.2)	(1.9)	(4.5)
Units built prior to 1950	%	53.5	69.8	78.3	74.2	76.1
Units built 1960 or later	%	25.0	16.9	10.5	11.6	8.9

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*Mahaska, Monroe and Wapello Counties.

Source: County and City Data Book - 1972, U.S. Bureau of the Census, GPO, 1973.

United States during the same period. Net out-migration during this period totalled approximately 12 per cent, which was partially offset by an excess of births vs deaths. Planning commissions having jurisdiction in the area indicate that migration is primarily a result of the lack of employment opportunities for younger people in the area which causes them to look elsewhere for jobs.

2.04312 Population in the Primary Area was approximately 52 per cent female and 99 per cent caucasion according to 1970 census figures. These percentages are comparable to statewide averages while national figures show approximately the same percentage of women (51 per cent) but a lower percentage of whites (88 per cent). The median age of the Primary Area population (34.5) is greater than that for both the state (29.1) and the nation (28.3) due primarily to the fact that almost 16 per cent of the Primary Area population is 65 years of age or older as compared to approximately 12.5 per cent for Iowa and 10 per cent for the nation. The median education (12 years) is comparable to state and national medians but the percentage of college graduates in the three county area is substantially lower than that of either Iowa or the nation.

2.04313 Residents of the Primary Area are located primarily in urban areas (61.2 per cent), which is a pattern also exhibited on state and national levels. Unlike state and national patterns, however, most of the rural residents are found in non-farm settings.

2.04314 The median family income in the three county area is $1000 to $1500 less than state or national medians. This is partially due to the high percentage of older people in the area who are living on fixed incomes. The high percentage of families below the low income level also has a negative effect on median family income.

2.04315 Available housing in the Primary Area consisted of approximately 27,000 year-round units in 1970. This represents a loss of about 1.2 per cent from the number available in 1960. Of the units available in 1970, 78 per cent were built prior to 1950, while only 10.5 per cent were constructed after 1960. It appears that available housing in the Primary Area is significantly inferior to average housing in both Iowa and the United States.

2.04316 In their 1975 Areawide Overall Economic Development Plan (OEDP), the Area XV Regional Planning Commission indicated the capacities of both water and sewer facilities for most communities throughout the three county area were more than adequate to handle present and projected loads well into the future.

2.04317 The preceeding paragraphs in this subsection describe existing conditions in the Primary Area with respect to certain sociological factors and community services. Future values for these same items will depend largely upon the degree of success with which the Area XV OEDP is implemented. If the OEDP should be 100 per cent successful, the entire profile of the area would change significantly by the year 2000. One objective of the OEDP is self-sustaining economic growth by the year 2000. In order to achieve this goal, job opportunities must be created to encourage the younger people to stay in the area. If these opportunities can be created, the median age will be lowered and the median income will increase, thereby creating additional tax revenues. These revenues can then be invested back into the community in the form of housing and other services in order to establish a more attractive environment and increase the overall standard of living. This rejuvenated community would be able to attract more people and theoretically the process would continue enabling the community to sustain growth. This highly simplified analysis of the effect of OEDP indicates the theoretical changes that should occur with the successful implementation of the plan.

2.04318 Another possibility to consider is that the OEDP will meet with little success, in which case the three county area can, at best, hope to stabilize its economic condition. If current trends were to continue, it is probable that the Primary Area would continue to experience relatively low level economic activity and sociological factors such as those discussed in prior paragraphs, would show no improvement.

2.04319 The actual degree of success which the OEDP will achieve is difficult to project but certain beneficial affects will likely accrue to the Primary Area as a result of efforts to implement the plan. The magnitude of effects on sociological factors in the three county area will depend largely on the degree of the OEDP's success.

2.0432 Ottumwa. The city of Ottumwa is located in Wapello County approximately 8 miles southwest of the Station Site and is the nearest city offering a full range of public facilities and services (Appendix G, Table G-3). The sociological character of Ottumwa is, for the most part, comparable to that of the Primary Area, as can be determined from an examination of Table 2-9. The most notable difference between Ottumwa and the Primary Area is that the level of income is higher in Ottumwa. The median family income is higher by approximately $600, while the percentage of families below the low income level is significantly lower. It should be noted, however, that state income levels are still significantly above those in Ottumwa.

2.04321 A 1972 study by the Ottumwa City Plan and Zoning Commission entitled "Comprehensive Plan For Ottumwa"[15] examined the public facilities and services of Ottumwa in light of future planning needs. The items addressed in this study include housing, water, sewer, school, recreational, health care and fire facilities.

2.04322 Housing in Ottumwa is decidedly substandard. As previously noted, approximately 76 per cent of the total year-round units in 1970 were built prior to 1950, while only 9 per cent were built in 1960 or later. A survey of 10 selected Iowa cities shows that while Ottumwa ranked third in population, it was second in the number of housing units lacking some or all plumbing facilities and tenth in the median value of owner-occupied housing and contract rent per rental unit. There were 74 homes for rent and approximately 125 for sale in mid-1974, as well as three mobile home parks, including one of the finest in the state. The housing situation has tightened recently as a new food processing plant added 200 employees to the City total, a new Hormel plant will employ approximately 500 in 1976, and expansion of existing industries is expected to add 50 to 100 jobs before year-end.

2.04323 The previously mentioned planning study for Ottumwa also indicated that new water and sewage treatment plants had recently been built. The new water and sewer facilities are rated at 12 mgd and 5 mgd respectively. These facilities were at the time of the study experiencing peak loads of 6 mgd and 4.1 mgd respectively and are considered more than adequate to handle expected needs well into the future.

2.04324 In the 1972 report it was determined that school facilities in the Ottumwa area were seriously lacking. This fact is obvious from an examination of the following tabulation.

	Elementary	Jr. High	Sr. High	Total
Fall 1971 enrollment	4,251	2,531	1,975	8,757
Fall 1971 capacity	4,325	1,625	1,400	7,350
Number of schools	13	3	1	17
Number of schools at or over capacity	6	3	1	10

Expansion of school facilities should receive a high priority in future City plans.

2.04325 Ottumwa has more than adequate land reserved for parks. National Park Service Standards recommend one acre of park land per 100 people. Ottumwa, with 30,000 people and 765 acres in park land, more than meet this standard. However, much of this park land is underdeveloped and many basic facilities are lacking. In order to meet recreational needs in future years, more efficient use and development of the park land will be required.

2.04326 Health care facilities in Ottumwa are generally of high quality, well equipped and well maintained. These facilities include 2 modern hospitals with 368 beds. Present and proposed fire facilities in Ottumwa should provide adequate protection for the community. A police force of approximately 40 officers appears to provide adequate protection to residents, as evidenced by comparison of crime rates with similar cities in Iowa.

2.0433 Other Communities. Other communities in the vicinity of OGS include Chillicothe, which is adjacent to the Station Site, and Eddyville, which is approximately 8 miles northwest. Chillicothe is a "bedroom" community with 126 residents in mid-1974 and no shopping facilities or municipal services. The town's only commercial enterprise is a small grain elevator. A county water system is currently under construction in the area. Ample space is available for mobile home parking, and a few vacant houses could possibly be renovated for rental or purchase. Due to lack of facilities and employment opportunities, Chillicothe could be expected to continue to experience low-level economic activity in the absence of OGS[10]. Eddyville is a community of 970 persons, with local shopping facilities and a normal range of small-town community services including a weekly newspaper. Eddyville is also the site of a large consolidated school district, with both elementary and high schools serving an area which includes Chillicothe and the Station Site. Available housing is very limited, but ample space is available for parking mobile homes or establishment of a mobile homes park. Local industries include a sawmill, packing house, and feed company. Limited opportunities exist for local employment.

2.044 Zoning Regulations. The OGS plant site has generally been in agricultural production with the obvious exception of roads and farm residences. The station site is presently zoned for heavy industry.

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7. "Regional Economic Information System," Bureau of Economic Analysis (BEA), Department of Commerce, October 16, 1974; Monroe, Mahaska and Wapello Counties, Iowa.

8. Personal Correspondence, Lloyd C. Stuber, Agricultural Statistician, Iowa Crop and Livestock Reporting Service, Iowa Department of Agriculture, May 16, 1975.

9. Personal Correspondence, J. Elliot Hibbs, Research and Statistics Division, Iowa Department of Revenue, May 28, 1975.

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12. Business Conditions Digest, Statistical Indicators Division, Series ES-1, Commerce Department, Social and Economic Statistical Administration, Economic Analysis Bureau, June 1975.

13. Personal Correspondence, Ashur Tamras, Federal Reserve Bank of Chicago, August 1, 1975.

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14. "Retail Sales and Use Tax," Research and Statistics Division, Department of Revenue, Iowa, (Quarterly Reports) 1950-74.

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2.05 Archaeology. During May 1975, an intensive surface survey was made of the Ottumwa Station site to locate cultural evidence of past human occupations, both prehistoric and historic. The survey was conducted by a qualified archaeologist with the Environmental Research Center, Iowa City, Iowa. A total of 13 sites were located as a result of the study. The majority of the sites appeared to have minor archaeological significance.

2.051 The findings of the Environmental Research Center were forwarded to the Office of the Iowa State Archaeologist and to the Iowa State Historic Preservation Officer. It was recommended that further studies be conducted to determine the significance of the 13 prehistoric and historic sites identified.

2.052 From October through December 1975, further archaeological studies were conducted under the direction of the State Archaeologist. In addition to personnel from the Office of the State Archaeologist, members of the Southeast Chapter of the Iowa Archaeological Society assisted with the field studies. The subsoil was exposed with a roadgrader at each site previously identified. A backhoe also was used to excavate a trench in the roadgrader cut. An archaeologist then evaluated the cleared area and trench. Two additional sites were identified.

2.0521 The Iowa State Archaeologist also made a thorough search of the National Register of Historic Places and other appropriate records for the presence of historic places on or near the OGS site and none were found.

2.053 The State Archaeologists' report is included in Appendix A. It was recommended that no further archaeological work be conducted on ten sites (13WP15, 13WP16, 13WP17, 13WP18, 13WP19, 13WP21, 13WP23, 13WP25 prehistoric component, 13WP26 and 13WP27).

2.054 Additional studies were recommended on four sites; i.e., 13WP13, 13WP14, 13WP22 and 13WP25. These investigations involved primarily more clearing, exposure of subsoil, and collection and evaluation of materials from the sites. Site 13WP28 was considered significant enough to warrant preservation. This site will not be disturbed by the planned project. Additional studies on the above sites were carried out as recommended.

2.055 The State Archaeologist by letter date May 11, 1976 informed Iowa Southern Utilities Company the final phase of archaeological work was completed and that the entire area was clear for construction insofar as cultural resources were concerned. This was followed on June 29, 1976, by the State Historic Preservation Officer's letter clearing the site for construction.

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2.06 Aquatic Ecosystems

2.061 Introduction. The Des Moines River and Avery Creek are typical of midwest rivers and small streams. In-depth studies of the aquatic ecosystems in the vicinity of the proposed power generating facility have not been conducted until recently. These studies were conducted during the Summer and Fall of 1975 on the Des Moines River upstream from Chillicothe, Iowa to a point just north of the Avery Creek confluence and including Avery Creek for a distance of about 2 miles upstream from its mouth.

2.0611 Studies were extended farther upstream on the Des Moines River for benthic macroinvertebrate samples to include a sampling site near the Highway 137 bridge as it crosses the river just south of Eddyville.

2.062 Sources of Information

2.0621 Little historical information is available concerning the aquatic ecosystems or water quality of the Des Moines River and Avery Creek in the study area. Water quality studies for the entire Des Moines River have been summarized in the 1975 Water Quality Report published by the Iowa Department of Environmental Quality[1]. In general, the major water quality problems occurring in the Des Moines River appear to be physical degradation related to erosion and bacteria. Dissolved oxygen and ammonia violate Iowa stream standards at times. While dissolved oxygen problems have decreased in recent years, problems continue to exist below major municipal discharges, particularly during low flow periods. Lead, zinc, and cadmium concentrations have exceeded Iowa standards in the river below Des Moines but only lead appears to have frequently violated stream standards. The sources of these heavy metals is unknown. Concentrations of BOD appear to decrease slightly below Red Rock Reservoir. The reservoir has a cleansing effect and in addition to reducing BOD levels also removes large amounts of silt and thus reduces turbidity values downstream.

2.0622 During 1973 and 1974 a limited water sampling program was conducted by the Iowa State Hygienic Laboratory at Chillicothe, Iowa[2]. Samples were taken from the Chillicothe Bridge in June and October 1973, and February 1974. Generally, little variation was apparent during the period and water quality was relatively good. Dissolved oxygen concentrations ranged from 8.2 to 12.8 mg/l while BOD_5 values varied from 2 to 5 mg/l. Ammonia nitrogen values were relatively low (<0.01 to 0.28 mg/l) but nitrate values were high. A maximum of 5.5 mg/l NO_3 as N was observed during February.

2.0623 Studies were also conducted in the study area in conjunction with the preparation of the present environmental impact statement. Four water quality sampling points were located within the project area (Figure 2-16): 1) Chillicothe Bridge on the Des Moines River (Lower Des Moines Station); 2) Des Moines River approximately 10-15 yards above the Avery Creek junction (Upper Des Moines Station); 3) Avery Creek at its confluence with the Des Moines River (Lower Avery Creek Station); and 4) County Road Bridge as it crosses over Avery Creek within the proposed site (Upper Avery Creek Station).

2.0624 Water quality analysis from samples taken at these four stations were made on a monthly basis from June-September 1975. Data on the water quality parameters analyzed from these stations are found in Appendix B.

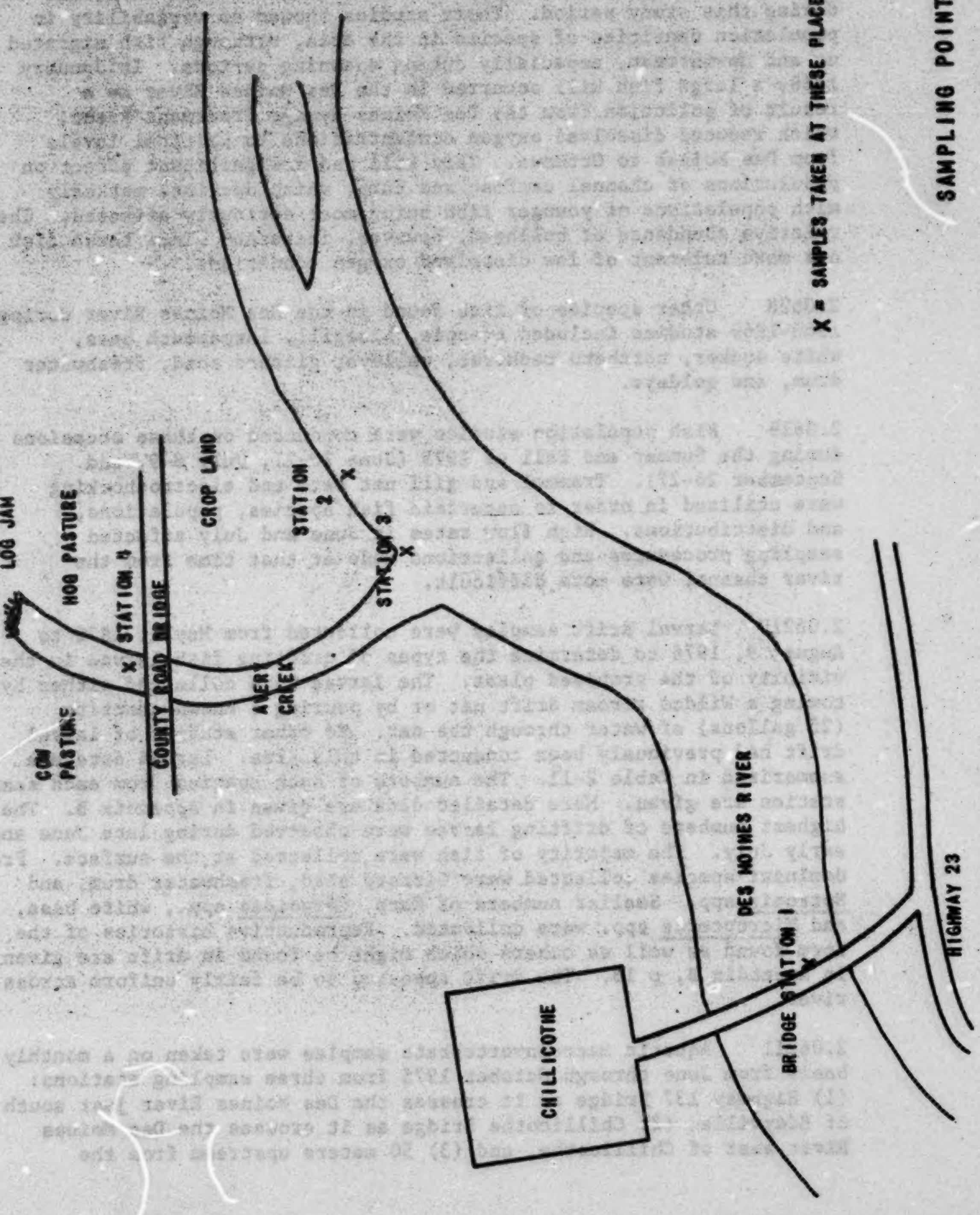
2.0625 With the exception of one study by Drum[3] of the diatoms of the Des Moines River, little published information is available concerning the planktonic or benthic communities of the river in the study area. Drum's studies of the lower Des Moines River, from 1961 to 1964, indicated that diatoms were the predominant planktonic form present. The species most frequently observed were: Diatom vulgare, Gomphonema divaceum, Melosira granulata, Nitzschia dissipatea, Nitzschia linearis, Nitzschia palea, Stephanodiscus hantzschii, Synedra acus and Synedra ulna.

2.0626 Studies of the plankton and periphyton communities were conducted from June-September 1975 at the four water quality sampling stations (see Section 2.0623). Phytoplankton were collected monthly, centrifuged and counted with the aid of a Sedgwick-Rafter counting cell. Zooplankton were collected twice in the summer and once in the fall by running known volumes of water through a small mesh plankton net. All zooplankton collected were classified into three familes: Copepods, Cladocerans, and Rotifers. Artificial substrates consisting of glass microscope slides were placed at the four stations in late June and removed in mid-July to determine periphytic communities. Biomass determinations and species present were determined for each station. Tabulated data for the phytoplankton, zooplankton, and periphyton studies are given in Appendix B.

2.0627 Previous fisheries studies of the Des Moines River have been conducted near Red Rock Reservoir by Mayhew and Mitzner[4,5,6] and Harrison[7] but none have specifically covered the present study area. Both reports indicate that good populations of channel catfish and rough fish such as carp, carpsucker, and buffalo fish occurred in the river from 1966 to 1968. The Mayhew and Mitzner reports of 1967 and 1968 indicated that channel catfish were the

FIGURE 2-16

SAMPLING POINTS



predominant fish of the Des Moines River near Red Rock Reservoir during this study period. Their studies showed no variability in population densities of species in the area, although fish migrated up and downstream, especially during spawning periods. In January 1968, a large fish kill occurred in the Des Moines River as a result of pollution from the Des Moines Sewage Treatment Plant, which reduced dissolved oxygen concentrations to critical levels from Des Moines to Ottumwa. This kill had a significant effect on populations of channel catfish and carp, which declined markedly with populations of younger fish being most seriously affected. The relative abundance of bullhead, however, increased since these fish are more tolerant of low dissolved oxygen conditions.

2.0628 Other species of fish found in the Des Moines River during 1966-1969 studies included crappie, bluegill, largemouth bass, white sucker, northern redhorse, walleye, gizzard shad, freshwater drum, and goldeye.

2.0629 Fish population studies were conducted on three occasions during the Summer and Fall of 1975 (June 20-21, July 8-9, and September 26-27). Trammel and gill net sets and electroshocking were utilized in order to ascertain fish species, populations, and distributions. High flow rates in June and July affected sampling procedures and collections made at that time from the river channel were more difficult.

2.06210 Larval drift samples were collected from May 1, 1976 to August 9, 1976 to determine the types of drifting fish larvae in the vicinity of the proposed plant. The larvae were collected either by towing a Wildco stream drift net or by pouring a known quantity (25 gallons) of water through the net. No other studies of larval drift had previously been conducted in this area. Larvae data are summarized in Table 2-11. The numbers of each species from each sampling station are given. More detailed data are given in Appendix B. The highest numbers of drifting larvae were observed during late June and early July. The majority of fish were collected at the surface. Predominant species collected were Gizzard shad, freshwater drum, and Notropis spp. Smaller numbers of Carp, Carpoides spp., white bass, and Micropterus spp. were collected. Reproductive histories of the form found as well as others which might be found in drift are given in Appendix B, p 18. The drift appeared to be fairly uniform across the river.

2.06211 Aquatic macroinvertebrate samples were taken on a monthly basis from June through October 1975 from three sampling stations: (1) Highway 137 Bridge as it crosses the Des Moines River just south of Eddyville, (2) Chillicothe Bridge as it crosses the Des Moines River east of Chillicothe, and (3) 50 meters upstream from the

Table 2-11

SUMMARY OF LARVAE DATA

Surface						Bottom					
Sample A			Sample B			Sample A			Sample B		
Species	No.	Relative Density (per 100 M^3)	Species	No.	Relative Density (per 100 M^3)	Species	No.	Relative Density (per 100 M^3)	Species	No.	Relative Density (per 100 M^3)
			May 1, 1976					May 1, 1976			
	0	0		0	0		0	0		0	0
			May 7, 1976					May 7, 1976			
	0	0		0	0		0	0		0	0
			May 20, 1976					May 20, 1976			
Notropis	4	3	White Bass	1	0.7		0	0	Carpoides spp.	1	1
			June 5, 1976					June 5, 1976			
Gizzard Shad Carpoides spp.	1 1	3		0 0	5		0 0	0	Unidentified	1	1
			June 17, 1976					June 17, 1976			
Gizzard Shad Freshwater Drum Notropis Unidentified	14 12 3 1	180	Gizzard Shad Freshwater Drum Notropis	5 2 1	270	Gizzard Shad Freshwater Drum Unidentified	3 1 1	10	Gizzard Shad Freshwater Drum Carp	4 2 1	18
			July 1, 1976					July 1, 1976			
Gizzard Shad Freshwater Drum Notropis	19 3 2	60	Gizzard Shad Freshwater Drum	13 4	47		0	0		0	3
			July 19, 1976					July 19, 1976			
Gizzard Shad Notropis	4 1	16	Gizzard Shad Unidentified	10 2	24	No Sample		No Sample	No Sample		No Sample
			August 9, 1976					August 9, 1976			
Unidentified	1	1			No Sample			No Sample			No Sample

Unidentified = Due to damaged condition

County Road Bridge as it crosses over Avery Creek. The samples were collected from artifical substrate which consisted of two barbeque baskets, each containing ten concrete spheres, suspended from a float which was tethered to a bridge or some other permanent structure. All collected specimens were classified to order and finally to genera where possible. Aquatic macroinvertebrate drift samples were taken only from the Eddyville station during the same time period to determine the types of drifting organisms in the river. The drift samples were taken by placing a Wildco drift net on a support and leaving it in the river for the first hour after sundown. Bottom samples were taken from ponds in the area using a Ponar dredge which was lowered into waist-deep water. Tabulated data of the macroinvertebrate organisms are given in Appendix B.

2.063 Des Moines River

2.0631 The Des Moines River in the study area is a typical midwest river with a predominantly sand and sand-gravel bottom. A current and bottom profile study of the river conducted on July 18, 1975, indicates that the main river channel is located on the west side of the river upstream of Avery Creek to a point some 2100 feet below the confluence of Avery Creek and the river. At that point the main channel then shifts to the east bank of the river with a small channel remaining along the west bank. Average depth in the channel at the time of the study was about 9 feet with the remainder of the river averaging 3 to 4 feet. Current velocities in the river varied from 1.58 to 3.48 fps with the highest values occurring just below the water surface in the channel area. The results of current and bottom profile studies are given in Appendix B.

2.0632 The hydrological characteristics of the Des Moines River in the study area are influenced primarily by the operation of the Red Rock Dam, located near Pella, Iowa. Although a number of small tributary streams enter the river between the dam and the plant site, their total drainage area is negligible when compared with that of the river upstream of the reservoir. A list of these streams and their drainage area is given in Table 2-12.

2.0633 Discharges from the reservoir are regulated to provide flood protection for the municipalities and agricultural lands from below the dam to the confluence of the Des Moines River with the Mississippi River. If the discharges at Ottumwa reach or are predicted to reach 18,000 cfs during the growing season or 30,000 cfs during the non-growing season, or if discharges at Keosaqua reach or are predicted to reach 22,000 cfs during the growing season or 35,000 cfs during the non-growing season, the discharges from the dam are reduced accordingly. Red Rock is also operated for low

Table 2-12

PRINCIPAL TRIBUTARIES JOINING THE DES MOINES RIVER FROM RED ROCK RESERVOIR TO PLANT SITE

Name of Tributary	Point of Confluence River Mile*	Drainage Area square mile
English Creek	137.0	112.0
Cedar Creek	127.9	423.0
North Avery Creek	105.3	60.3
South Avery Creek	104.0	51.6

*Miles above the mouth of the Des Moines River where tributary enters.

Source: Conservation Storage in Red Rock and Saylorville Reservoirs; Design Memorandum No. 3, U.S. Army Engineer District, Rock Island; 13 October 1961.

flow augmentation and it is required that a minimum of 300 cfs be released from the dam to satisfy the requirements at Ottumwa. The complete operational schedule for the dam is given in Table 2-13.

2.0634 Usually, the low flow period at Ottumwa occurs from August to October while high flows occur from April through June (see Section 2.02).

2.0635 In general the water quality of the Des Moines River was found to be good during the current study and does not differ significantly from that observed in earlier studies[2,4]. The water quality in this area is affected by several factors, including the retention in the Red Rock Reservoir which, as previously mentioned, probably improves the water quality and agricultural land runoff.

2.0636 Differences between the water quality of the two stations on the Des Moines River are small. Seasonal variations are apparent. Dissolved oxygen values varied from 5.1 to 7.9 mg/l with both the minimum and maximum values being observed at Station 2 just above the Avery Creek confluence. Alkalinity concentrations in the river ranged from 142 to 203 mg/l $CaCO_3$. Nitrate concentrations varied from 0.82 mg/l N in August to 7.8 mg/l N in July. High nitrogen concentrations are not unusual in many Iowa streams. Ammonia concentrations exhibited little variation ranging from 0.01 to 0.08 mg/l N. Fecal and total coliform values were relatively low as compared to other Iowa rivers. Total coliform values ranged from 200 to 3700 organisms/100 ml. Five-day BOD values ranged from 0.8 to 3.8 mg/l, with little differences occurring between the lower and upper Des Moines stations.

2.0637 River temperatures exhibited normal seasonal variations and no evidence of upstream thermal additions were apparent. The Iowa Southern Utilities' Eddyville Generating Station, located about 7 miles upstream of the study area is a small facility with a closed cycle cooling system. The Eddyville Station is an oil-coal fueled electric generating facility with a maximum capacity of 66 MWe. The station currently serves in an auxiliary capacity operating only intermittently. Water for station operation is withdrawn from the Des Moines River by three turbine pumps, each with a maximum pumping capacity of 1000 gpm. Normal operating conditions require about 2000 gpm and during the current stand-by operation the flow is 950 gpm (each 2 cfs). The Eddyville station uses a closed cycle cooling system and there is no thermal discharge; therefore, there is no effect on the thermal regime of the river as a result of operating the facility.

Table 2-13

LAKE RED ROCK--FLOOD CONTROL REGULATION SCHEDULE

Regulation Schedule	Lake Stage		Condition	Operation
A. Normal flood control operation.	Rising	I	16 December thru 20 April.	Maintain permanent pool level 725 by releasing inflow up to 22,000 cfs, then, permit pool level to rise with uncontrolled outlet discharge until elevation 750 is reached (corresponds to uncontrolled outlet discharge of 30,000 cfs) then continue to release 30,000 cfs as pool continues to rise, except as limited by Conditions A-II, and Schedule B.
	Rising	II	16 December thru 20 April, Discharge at Ottumwa or Keosauqua above, or forecast to exceed 30,000 cfs (corresponds to stage 10.8) respectively.	Release not less than 5,000 cfs to control flow to those discharges at respective stations insofar as possible except as limited by Schedule B.
	Falling, steady or rising	III	21 April thru 15 December. Lake at or above permanent pool elevation 725.	Release 18,000 cfs until lake reaches to permanent pool level, after which it shall be held at that level insofar as possible without exceeding release of 18,000 cfs, except as limited by Condition A-IV, and Schedule B.
	Rising	IV	21 April thru December. Discharge at Ottumwa or Keosauqua above or forecast to exceed 18,000 cfs (corresponds to stage 7.5) or 22,000 cfs (corresponds to stage 7.5) respectively including release in Condition A-III.	Release not less than 5,000 cfs to control flow to those discharges at respective stations insofar as possible except as limited by Schedule B.
	Rising	V	Any date, stage at, or above, or forecast to exceed 17.0 feet on Mississippi River gage at Burlington, Iowa, or 14.0 feet on Mississippi River gage at Quincy, Illinois.	During period corresponding to time Mississippi River is above forecast stages provided lake inflow is greater than 5,000 cfs, release not less than 5,000 cfs until lake elevation 755.5 is reached; then provided (a) lake inflow is greater than 15,000 cfs until lake elevation 763.5 is reached, or, (b) if lake inflow is between 5,000 cfs and 15,000 cfs release the inflow; then, if operation (a) was followed and at elevation 763.5,

Table 2-13 (Continued)

Regulation Schedule	Lake Stage	Condition	Operation
			provided (c) lake inflow is greater than 25,000 cfs release not less than 25,000 cfs until lake elevation 775 is reached, or (d) if lake inflow is between 15,000 cfs and 25,000 cfs release the inflow; then if operation (f) was followed release not less than 30,000 cfs, except as limited by Schedule B.
B. Large magnitude flood operation	Rising	VI Any date, lake elevation is rising and above or forecast to exceed elevation 775.	When predictions indicate that anticipated runoff from a storm will appreciably exceed the storage capacity remaining in the lake when operated under Schedule A, release rates will be in accordance with the following schedule:

Pool Elev.	Outflow cfs
775	30,000
776	35,000
777	40,000
778	45,000
779	50,000
780	60,000
780.5	80,000
781	100,000
781.5	115,000
782	130,000
783	130,000
784	130,000
785	130,000
785	Open spillway tainter gates as necessary to maintain lake elevation 785 until uncontrolled spillway and outlet conduit discharge prevails, then allow lake to continue rising with uncontrolled spillway and outlet conduit discharge.

Source: U.S. Army Engineer District. Rock Island. UMRB, Des Moines River, Iowa and Minn. Master Reservoir Regulation Schedule. June 26, 1968.

2.0638 Pesticides and heavy metal concentrations were relatively low in the present study as compared to other data collected on the Des Moines River[1]. The water quality data are summarized in Table 2-14 and complete results are given in Appendix B.

2.0639 Two major types of habitat occur in the Des Moines River, the channel portion and the shoreline areas. In the channel, the river bottom in the vicinity of Chillicothe has been characterized as one of transition between upstream alluvium and downstream rock ledge[8]. Shoreline habitats are greatly influenced by the river level. At high water stages many habitats are shaded by overhanging silver maple, sandbar willows, and cottonwoods. Quiet water areas are formed where the river backs up into drainage ditches, and there are not true riffle areas or sandbars. At low water, when the river recedes from the wooded shoreline, riffle areas and sandbars occur. Rubble and brush pile areas occur at intervals along the shoreline and are doubtless important habitat for a variety of species.

2.06310 Phytoplankton populations in the Des Moines River exhibited temporal variations in number and species composition. In general, similar numbers and species were found at the lower and upper river stations, although the lower station had a greater diversity of diatom species and the upper Station 2 had more species of green algae. The diatoms Cyclotella and Nitzschia were the dominant organisms observed at both stations. Blue-green algae counts were low and consisted of Anacystis, Anabaena, and Oscillatoria. Total plankton counts ranged from 1500 to 1800 organisms/ml. These numbers are generally low as compared to other midwestern rivers. Complete phytoplankton data can be found in Appendix B.

2.06311 Copepods dominated the zooplankton community during the summer months while Cladocerans were the predominant forms in the fall. Rotifers were not abundant at either of the two river stations.

2.06312 The artifical substrates at Station 1 (lower Des Moines River) were destroyed or lost, due to the fragile nature of the substrates. However, due to the similarities in water quality at Station 1 and Station 2 on the Des Moines River, the similar velocities at the two stations, and the similar nature of bank features it is unlikely that significant differences in community structure would occur between these stations. Species composition and biomass for Station 2 are found in Appendix B. Diatoms, chiefly Melosira and Cymbella were the dominant organisms developing on the substrates.

Table 2-14

SUMMARY OF WATER QUALITY DATA
JUNE-SEPTEMBER 1975

	Station 1 Lower Des Moines River		Station 2 Upper Des Moines River		Station 3 Lower Avery Creek		Station 4 Upper Avery Creek	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
pH	7.7	8.1	7.9	8.1	7.8	8.0	6.8	7.8
DO (mg/l)	6.6	7.7	5.1	7.9	5.3	7.9	4.9	9.0
Total Alkalinity (mg $CaCO_3$/l)	142	203	144	203	139	198	68	254
NO_3 (mg N/l)	.85	7.8	.82	7.6	.8	7.0	.05	.6
NH_3 (mg N/l)	.02	.06	.01	.08	<.04	.06	.04	.5
TOC (mg C/l)	7	12	5	11	7	12	11	23
Calcium (mg $CaCO_3$/l)	160	244	144	208	144	200	212	334
Orthophosphate (mg P/l)	111	.21	.12	.15	.08	.35	.01	.16
Total Phosphate (mg P/l)	.16	.39	.14	.40	.12	.83	.09	.73
Sodium (mg Na/l)	7.5	14	8.0	17	9.2	16	2.0	20
Potassium (mg K/l)	2.3	4.8	1.8	5.0	2.9	5.4	6.0	8.6
Magnesium (mg Mg/l)	17.4	52.0	22.0	64.0	23.0	64.0	18.0	56.0
Chloride (mg Cl^-/l)	16.0	24.0	16.5	24.0	15.0	23.0	5.0	11.0
Sulfate (mg SO_4^{-2}/l)	47	116	52	116	67	118	112	220
Silica (mg SiO_2/l)	3.9	9.1	4.2	9.2	4.2	9.5	1.2	4.3
Temperature (C)	22.6	28.2	20.0	27.8	21.8	28.0	21.0	28.0
Total Dissolved Solids (mg/l)	150	460	150	460	230	550	240	560
Turbidity (JTU)	15	39	18	42	16	40	12	34
Specific Conductance	407	590	395	700	407	590	577	788
BOD_5 (mg/l)	1.0	3.8	.8	3.4	1.5	3.1	3.5	8.2
Secchi Disc (meters)	1.5	.5	.25	.25	.25	.30	.25	.25
Total Coliforms (org/100 ml)	200	2000	300	3700	600	4300	1600	4100
Fecal Coliforms (org/100 ml)	50	560	10	1300	280	2500	800	1900

Source: Institute of Hydraulic Research, University of Iowa, 1975.

2.06313 Fish population studies made during the Summer and Fall of 1975 indicate the presence of a diverse fish community in this portion of the river (Table 2-15). The fish community includes a good base of forage species including carp and carpsucker as well as a number of predator species such as walleye and northern pike. No rare or endangered species have been reported in the literature or were found in the Des Moines River during the study.

2.06314 Fish found in the greatest abundance were carpsucker and carp. All species of carpsucker had a combined relative abundance of 50.6 per cent in June, 39.7 per cent in July, and 29.7 per cent in September. Carp were found in a relative abundance of 32.9 per cent in June, 42.2 per cent in July, and 10.7 per cent in September. Fishes of the genus Notropis were found to comprise 47.3 per cent of the September collections and, because of their preference for riffle areas, were more common during the lower river levels (Table 2-16). The large number of Notropis collected was no doubt due in part to sampling techniques and locations sampled. Locations sampled were either sand bars or shallow gravel areas in both the Des Moines River and Avery Creek. Bag seines were commonly used in the riffle areas and seine samples from these areas did contain large numbers of Notropis. Pfliegler (1975) states in "The Fishes of Missouri," that many species of shiners commonly inhabit shallow areas with gravel, rock or sand bottoms and their presence in the bag seine collections was not unexpected. It is acknowledged that sampling technique plays a major role in determining the abundance of various species in collections. However, due to the nature of the habitat in the vicinity of the Ottumwa Generating Station during the 1975 summer study the large number of these organisms collected is not surprising.

2.06315 Species composition in the study area is similar to that reported for upstream sections of the Des Moines River with the exception of the number of channel catfish and carpsucker (Mayhew and Mitzner[4,5,6] and Harrison[7]). This difference may be due in part to a pollution-caused fish kill between Des Moines and Ottumwa occurring during the Winter of 1968, which resulted in an estimated loss of 54 per cent of the channel catfish population (Mayhew and Mitzner[6]). According to studies by Mayhew, changes in fish population structure were the reduction of the numerical abundance of channel catfish and carp, while bullhead and river carpsucker increased. On the other hand, the reported low number of channel catfish in the present study area may merely reflect that the sampling methods used in the present study were not effective in collecting this species.

Table 2-15

FISH SPECIES LIST

Scientific Name	Common Name
Dorosoma cepedianum (LeSueur)	Gizzard shad
Esox lucius (Linnaeus)	Northern pike
Cyprinus carpio (Linnaeus)	European carp
Carpiodes carpio (Rafinesquie)	River carpsucker
Carpoides cyprinus (LeSueur)	Quillback
Carpoides velifer (Rafinesquie)	Highfin carpsucker
Notropis Spp.	Small cyprinids
Ictiobus cyprinellus (Valenciennes)	Bigmouth buffalo
Ictiobus bubalus (Rafinesque)	Smallmouth buffalo
Moxostoma macrolepidotum (LeSueur)	Shorthead redhorse
Ictalurus punctatus (Rafinesque)	Channel catfish
Ictalurus melas (Rafinesque)*	Black bullhead
Ictalurus natalis (LeSueur)*	Yellow bullhead
Pylodictis olivaris (Rafinesque)**	Flathead catfish
Noturus flavus (Rafinesque)**	Stonecat
Monrone chrysops (Rafinesque)	White bass
Micropterus salmoides (Lacepede)*	Largemouth bass
Lepomis cyanellus (Rafinesque)*	Green sunfish
Lepomis macrochirus (Rafinesque)*	Bluegill
Pomoxis annularis (Rafinesque)*	White crappie
Pomoxis nigromaculatus*	Black crappie
Stizostedion vitreum vitreum (Mitchell)	Walleye
Aplodinotus grunniens (Rafinesque)	Freshwater drum

*Collected only in Avery Creek.

**Collected only in the Des Moines River.

All others collected in both the Des Moines River and Avery Creek.

Sources: Bailey (1970) A List of Common and Scientific Names of Fishes from the United States and Canada. American Fisheries Society Special Publication No. 6, Washington, D. C.

Eddy (1957) How to Know the Freshwater Fishes. Wm. C. Brown Company, Dubuque, Iowa.

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Table 2-16

RELATIVE ABUNDANCE OF FISH SPECIES SAMPLED IN THE DES MOINES RIVER IN 1975

Species	June 20-21 No.	June 20-21 Relative Abundance	July 7-8 No.	July 7-8 Relative Abundance	September 26-27 No.	September 26-27 Relative Abundance
Bigmouth Buffalo	1	1.3	3	3.6	2	0.5
Carp	26	32.9	35	42.2	45	10.7
Carpsucker, Highfin	11	13.9	2	2.4	3	0.7
Carpsucker, River	29	36.7	27	32.5	87	20.7
Carpsucker, Quillback	-	-	4	4.8	35	8.3
Channel Catfish	-	-	-	-	9	2.1
Flathead Catfish	-	-	-	-	1	0.2
Freshwater Drum	-	-	-	-	5	1.2
Gizzard Shad	-	-	-	-	15	3.6
Northern Pike	-	-	1	1.2	2	0.5
Notropis	-	-	-	-	199	47.3
Shorthead Redhorse	-	-	-	-	9	2.1
Smallmouth Buffalo	1	1.3	4	4.8	4	0.9
Stonecat	-	-	-	-	1	0.2
Walleye	-	-	-	-	4	0.9
White Bass	1	1.3	2	2.4	-	-
Total	79		83		421	

Source: Institute of Hydraulic Research, The University of Iowa, 1975.

2.06316 Larval or postlarval stages of Notropis and other Cyprinidae were collected from the Des Moines River. On July 8, 1975 two unidentified Cyprinidae were taken from the east bank and on July 18, one Notropis was collected from the west bank. High flows in the Des Moines River made larval sampling at that time difficult. Spawning and larval drift of species found in the river is probably more common in the backwaters and tributaries such as Avery Creek than in the river itself.

a. In many forms with a pellagic larval stage, such as white bass and drum, spawning frequently takes place in streams tributary to the parent stream. Other forms may spawn in various habitats. For example, crappie, perch and sunfish prefer shallow water areas with gravel bottoms and areas of vegetation, twigs and leaves, a habitat type far more common in Avery Creek than in the Des Moines River. Catfish frequently spawn in undercut banks or among piles of driftwood and logs, while carp may deposit eggs at random over rocks and logs in shallow water areas. Preceding spawning, walleye frequently move into the tributaries out of larger stream systems.

b. In addition to actual spawning activities, however, backwater areas along the Des Moines River are also essential as nursery areas for many species. During the 1975 sampling more young-of-the-year fish were collected from Avery Creek than were collected from the Des Moines River. Part of this discrepancy was partially due to the difficulty in sampling the main river with minnow and bag seines, but considering the habits of these forms it is reasonable to assume that the small creeks and backwater areas are important nursery habitats for the river.

2.06317 Macroinvertebrate population studies made during the Summer and Fall of 1975 indicated a poor-to-moderately diverse macroinvertebrate community in this portion of the Des Moines River (see Appendix B). This is apparently due to the influence of Red Rock Reservoir which prevents normal drift of upstream organisms to colonize downstream sites (Merkley[11]). The organisms which predominate below the reservoir are largely filter-feeders that feed on the particulate matter coming from the reservoir. This is documented by the occurrence of the relatively large number of hydropsychid caddisflies (Trichoptera).

2.06318 Three species of caddisflies (Trichoptera) were the predominant organisms in the Des Moines River samples. Two species of Hydropsyche and one species of Potamyia had a combined relative abundance of 88.6 per cent in June, 79.0 per cent in July, 79.7 per cent in August, and 90.8 per cent in September. The October sample was decidely more diverse with stoneflies (Plecoptera) appearing in the samples for the first time. The combined relative abundance of the specimens in October showed stoneflies (Plecoptera) with 2.3 per cent, mayflies (Ephemeroptera) with 31.7 per cent, species of Diptera with 18.2 per cent, and caddisflies (Trichoptera) at a lower level than previously with 47.7 per cent.

2.06319 There was a definite seasonal response of the fauna with respect to velocity and temperature. For example, the Simulidae (Diptera) were decidedly more abundant in the late spring and early summer when the river was flowing high, fast, and cool; these organisms gradually became less abundant until they were completely absent in the October sample. The midge larvae (Chironomidae) quickly replaced them since the midges respond more favorably to reduced velocity and warmer temperatures. This replacement pattern was also evident in some of the mayfly (Ephemeroptera) species. The two species of *Baatis* were better able to compete for available habitat and food when the velocity was high but were replaced by the more sluggish *Stenonema* when the velocity was reduced in the late summer and fall. Stoneflies (Plecoptera) appear to be more sensitive to higher temperatures than most of the other macroinvertebrates and they did not appear in the samples until October. There is no obvious reason as to why stoneflies only appeared at the station near Chillicothe and not farther upstream at Eddyville.

2.06320 Differences between the numbers and species composition of the macroinvertebrates collected at the two stations on the Des Moines River are due to the natural but variable colonization patterns of the organisms and the placement of the artificial substrate. Though site selection is carefully chosen, it is not always possible to duplicate conditions from site to site especially when considering the effects of water velocity.

2.06321 The organisms appearing in the drift samples were representative of those sampled from the artificial substrate both in numbers and composition. No rare or endangered macroinvertebrate species were found in the Des Moines River during this study.

2.06322 Pesticide levels in several species of fish collected from the Des Moines River on July 21, 1975 are given in Table 2-17. Levels were generally low as compared to levels in fish taken from other Iowa streams[9,10]. Heptachlor and degradation products of DDT were the compounds present in highest concentrations.

Table 2-17

FISH PESTICIDES RESIDUES
PARTS PER BILLION

Species	Length Inches	Weight grams	Heptachlor	Heptachlor Epoxide	Aldrin	Dieldrin	p,p' DDT	p,p' DDE	p,p' DDD
Carp (Des Moines River)	15	892.9	8.2	-	-	-	-	18.8	24.2
Walleye (Des Moines River)	11	186.6	8.7	-	-	-	-	15.6	19.5
Carp (Avery Creek)	12	352.3	19.5	36.4	3.5	75.4	-	27.5	23.8
Largemouth Bass (Avery Creek)	12	463.7	36.0	32.4	-	-	21.0	24.4	10.4

Source: Institute of Hydraulic Research, The University of Iowa, 1975.

2.064 Water Bodies on the Plant Site

2.0641 There are no significant ponds on the plant site. The only significant stream flowing through the plant site is Avery Creek, although there are drainage ditches along the county road traversing the site. Avery Creek is a small stream with a drainage area of 60.3 square miles which enters the west side of the Des Moines River at River Mile 105.3. Normally the flow in the creek is low as is the average velocity. During the study velocities varied from 0.5 in June to 3.30 fps in July. Precise flow information is not available as there are no U.S. Geological Survey gaging stations located on the stream.

2.06411 The macroinvertebrate populations of Avery Creek changed dramatically during the study period of 1975. This change was accompanied by rapidly falling water levels in Avery Creek. While the creek was touching its banks and flowing downstream (primarily during the early summer), the fauna, although not as diverse or abundant as in the Des Moines River, was characteristic of a stream fauna with representatives of mayflies (Ephemeroptera), caddisflies (Trichoptera), and Diptera. But as soon as the water ceased to flow and began to stand in pools, the fauna changed to resemble the fauna in ponds of the surrounding region. For example, the midge (Chironomidae) larvae greatly increased and constituted more than 98 per cent of the total organisms when the water stopped flowing. This type of predominance by the midge larvae is characteristic of aquatic organisms in an intermittent stream when the water ceases to flow and begins to stand in pools. The presence of beetles (Coleoptera), annelids, and damselfly (Odonata) nymphs helped to characterize the pond-like nature that the creek had assumed (see Appendix B).

2.06412 Bottom samples were taken from each of the five ponds in the proposed construction site. The samples consisted of duplicate grabs using a Ponar dredge which was lowered into waist-deep water. The fauna was characteristic of ponds throughout the region and the Midwest. The composition of the organisms from the ponds showed more diversity than those found in Avery Creek, however, the number of specimens per square meter was not nearly as great. The apparent differences in species composition may be an artifact of the sampling technique as the artificial substrate sampler in Avery Creek was not especially adapted to sampling Hexagenia, Gyrinidae, Hemiptera species, or Physa (see Appendix B). There was nothing unusual about the pond samples and no rare or endangered species were found during this study of the ponds.

2.0642 Avery Creek is bordered for the most part by woodlot stands, predominantly overhanging silver maple and pastureland. At its confluence with the river, the creek contains several log jams and brush piles. The water is quiet and the current from the river does not appear to cause appreciable swirls. Bottom type at the confluence is primarily mud. The section of the creek immediately upstream from the mouth also has a mud bottom with scattered fallen trees and log jams. At the low river levels observed during the June to September study water in this section was shallow but sufficient to maintain a connection with the river. The middle section of the creek about 500 yards above the confluence has a predominantly silt and mud bottom. This section is relatively shallow and at low river levels much of the stream bed is exposed. The upper section of Avery Creek in the vicinity of the existing County Road Bridge contains a rock-lined shore and exposed rock bottom. Habitat diversity is high during both high and low flow periods. During low flow periods isolated pools, rocks and rubble, and a few pockets of mud exist in this area. Above the County Road Bridge, the creek contains log jams and deep pockets of water which are isolated at low river levels. The bottom type in this area is predominantly silt and mud.

2.0643 The water quality of Avery Creek was found to be relatively good during the current study and was adequate to support aquatic biota which would normally occur in this stream. The primary factor affecting the water quality of Avery Creek is agricultural land runoff.

2.0644 Dissolved oxygen values varied from 4.9 mg/1 to 9.0 mg/1 with both maximum and minimum values occurring in the upper section of Avery Creek. In general, high dissolved oxygen values were observed in the upper portions of Avery Creek. Alkalinity values in Avery Creek ranged from 68 mg/1 in September to 254 mg/1 $CaCO_3$ in August. Nitrate concentrations ranged from 0.05 mg N/1 to 7.0 mg N/1. In general, the values observed at the Lower Avery Creek station were higher than those obtained from Upper Avery Creek. Ammonia concentrations exhibited little variations ranging from 0.04 to 0.5 mg/1. Fecal and total coliform values were low as compared to other Iowa streams. Total coliform values ranged from 600 to 4300 organisms/100 ml while fecal coliform values ranged from 280 to 2500 organisms/100 ml. In general, coliform values found in Avery Creek were lower than those observed in the Des Moines River.

2.0645 Five-day BOD values, sulfate and potassium concentrations tended to be higher in the upper section of Avery Creek than at the mouth and these values for both stations were higher than the Des Moines River values. This is probably a direct result of agricultural runoff into the creek and the small size of the drainage basin. Water quality data is summarized in Table 2-14 and complete results are given in Appendix B.

2.0646 Phytoplankton populations in Avery Creek exhibited considerable variation in number and species composition, both temporally and between the lower and upper creek stations. Station 4, located on Upper Avery Creek, exhibited higher total counts and differed from Station 3, located at the mouth of Avery Creek, in species composition. Upper Avery Creek appears to support a wider variety of organisms, especially green algae and flagellates, whereas Lower Avery Creek supports a wider variety of diatoms and lower green algae populations. This is probably due to the greater habitat diversity at Station 4, the low velocity of the creek in this section, and the high nutrient input into the creek resulting from agricultural land runoff. Station 3 exhibited lower green algal counts, probably due to the shading effects of the woodlots along the bank. Blue-green algal counts were low at both stations and consisted of Anacystis, Oscillatoria, and Phormidium. Total plankton counts ranged from 1300 to 10,000 organisms/ml. Complete phytoplankton data can be found in Appendix B.

2.0647 Zooplankton distribution was patchy. In June Copepods were dominant at both stations while in July Copepods and Cladocerans were present in approximately equal numbers at Station 3 while Copepods dominated the zooplankton at Station 4. Rotifers were not abundant at either station.

2.0648 Analysis of the species composition of periphyton at the upper and lower stations on Avery Creek indicate significant differences between the periphytic communities at the two stations. Both species diversity and biomass values were lower at the Lower Avery Creek station than at the upstream site. These differences were probably due to the overhanging trees and resultant reduced light intensity at the station. Because of the frequent water level fluctuations in Upper Avery Creek, the periphytic community structure is probably unstable and the high productivity found in this section of the creek may not remain consistently higher than that found in the lower portions of Avery Creek.

2.0649 Avery Creek provides habitat for such activities as spawning, recruitment, and feeding of fish, especially during the higher river levels in June and July. White crappie of all age classes was collected from Avery Creek including a number of postlarval fish. Larval or postlarval walleye, gizzard shad, freshwater drum, largemouth bass, and bluegill were also collected in drift net sets. The results of the larval studies are given in Table 2-18. The creek is also a feeding area for forage fish such as carpsucker, carp, and largemouth buffalo, all of which were found in relatively large numbers (see Table 2-19). Adult fish of the predator species (northern pike, walleye, and channel catfish) were netted or electroshocked from the creek. Avery Creek appears to be utilized as a spawning and nursery area for white crappie, walleye, gizzard shad, and freshwater drum. No rare or endangered species were found during the current study in Avery Creek.

2.06410 Pesticides in several species of fish collected from Avery Creek on July 21, 1975 are given in Table 2-17. Heptachlor, heptachlor epoxide, and degradation products of DDT were the compounds present in highest concentrations.

Table 2-18

LARVAL FISH SAMPLED IN AVERY CREEK IN 1975

June 21, 1975	
6	Clupidae (Gizzard Shad)
4	Cyprinidae
1	White Crappie

July 8, 1975	
3	Cyprinidae
28	Freshwater Drum
1	Notropis
1	Unidentified

July 18, 1975	
9	Centrarchidae
8	Notropis

July 30, 1975	
11	Notropis
2	Centrarchidae

Source: Institute of Hydraulic Research, The University of Iowa, 1975.

Table 2-19

RELATIVE ABUNDANCE OF FISH SPECIES SAMPLED IN AVERY CREEK IN 1975

	June 20-21		July 7-8		September 26-27	
Species	No.	Per Cent Abundance	No.	Per Cent Abundance	No.	Per Cent Abundance
Bigmouth Buffalo	8	3	29	6.9	1	0.5
Black Bullhead	-	-	-	-	13	5.9
Bluegill	-	-	1	0.2	9	4.1
Carp	35	13.2	17	3.6	14	6.4
Carpsucker, Highfin	28	10.6	16	3.4	-	-
Carpsucker, River	105	39.8	157	29.1	37	16.8
Carpsucker, Quillback	5	1.9	2	0.4	6	2.7
Channel Catfish	1	0.4	5	1.1	2	0.9
Freshwater Drum	-	-	1	0.2	3	1.4
Gizzard Shad	15	5.7	229	48.7	85	38.6
Green Sunfish	-	-	-	-	1	0.5
Largemouth Bass	1	0.4	3	0.6	4	1.8
Northern Pike	5	1.9	6	1.3	3	1.4
Notropis	6	2.3	1	0.2	16	7.3
Shorthead Redhorse	-	-	1	0.2	-	-
Smallmouth Buffalo	3	1.1	3	0.6	-	-
Walleye	10	3.8	2	0.4	2	0.9
White Bass	4	1.5	2	0.4	3	1.4
White Crappie	34	13.0	9	1.9	21	9.5
Yellow Bullhead	1	0.4	-	-	-	-
Unidentified	3	1.1	-	-	-	-
Total	264		470		220	

Source: Institute of Hydraulic Research, The University of Iowa, 1975.

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2.07 Terrestrial Environment of the Ottumwa Generating Station Site

2.071 Introduction. The terrestrial environment of the Ottumwa Generating Site is a mosaic of agricultural fields, grasslands, and forests bordering the Des Moines River and traversed by a small stream (Avery Creek), a county highway, and the tracks of the Burlington Northern Railroad. There are no wetlands on the plant site. To describe the terrestrial aspects of the area, field visits were made from June 1975 into October 1975. Surveys of the vegetation, mammals, birds, other vertebrates, insects and other invertebrates, ecological function and successional status were made. Much of the information was obtained directly in the field, while some was gleaned from the literature.

2.072 Vegetation

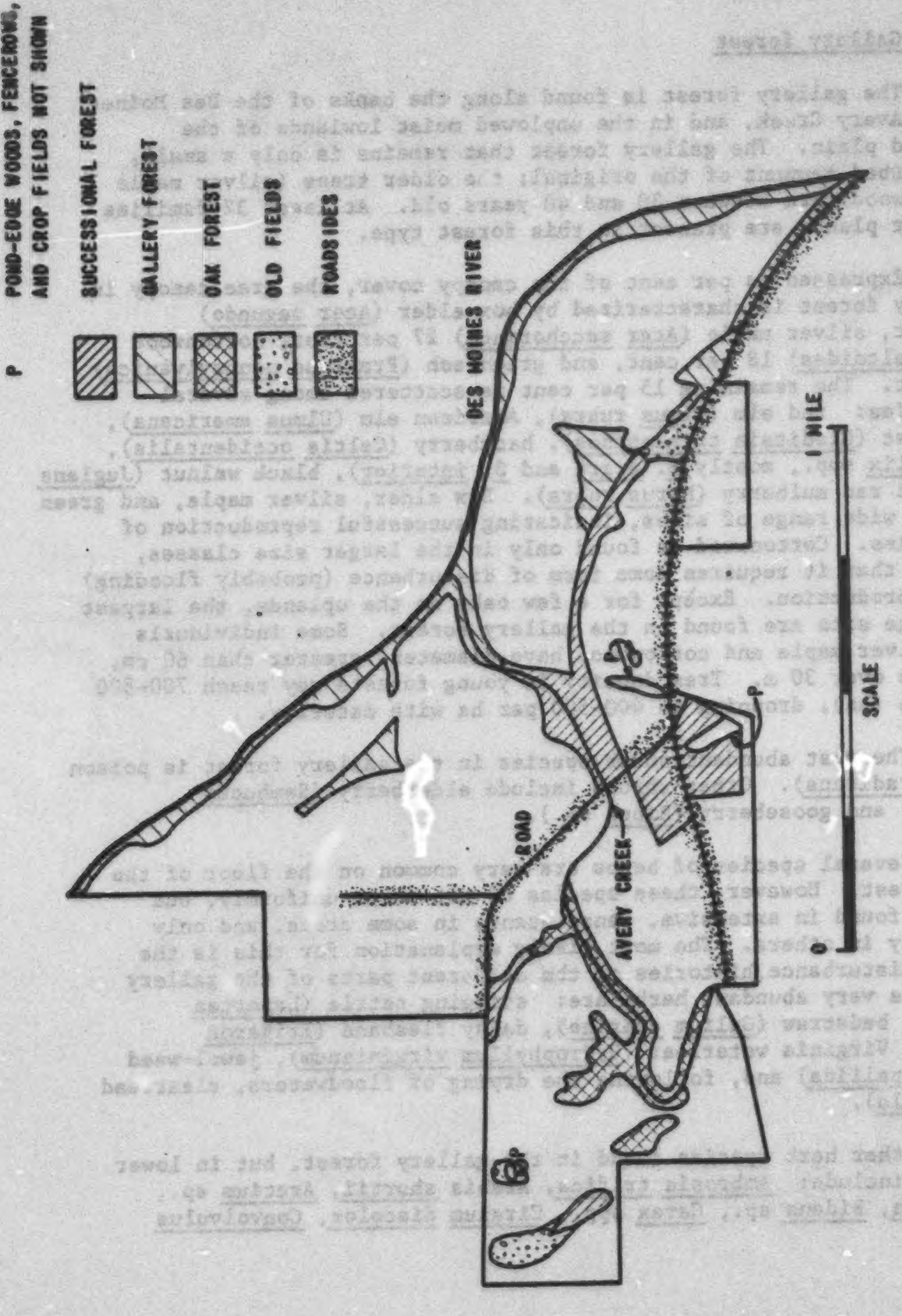
2.0721 General.

a. The two major vegetation formations represented on the Ottumwa Site (exclusive of agricultural fields and pastures) are forest and grassland. Of the forests, there are four types: 1) gallery forest along the stream-sides, 2) pond-edge woods, 3) disturbed upland forests in early succession, and 4) upland oak forest. There is no natural forest, that is, although some of the species present are also found in pristine forest. On the Ottumwa Site all the forests show sign of moderate to severe disturbance, by clearing, cutting and grazing. Figure 2-17 is a vegetation map.

b. Grasslands are represented by three types: 1) fencerows and field edges, 2) old fields, and 3) roadsides and railroad rights-of-way. As is true of forests, there are no native or natural prairies on the site. The grassland vegetation most similar to that of the presettlement condition is found along the tracks of the Burlington Northern Railroad, in one small area (about 1/2 hectare). This area has one of the common tall grasses of the prairie, Indian grass (Sorghastrum nutans), and some of the forbs (e.g., goldenrods, Solidago spp.; asters, Aster spp.; milkweeds, Asclepias spp.), but it is lacking the great diversity of species, the several tall grasses, and the functional integration of the true prairie. The original vegetation of the site has been completely altered by Man's activities, including burning, plowing, cutting, and livestock grazing.

c. The vegetation of the Ottumwa Site contains at least 51 vascular plant families. The five families with the most species are: composite or sunflower family (Compositae), grass family (Graminae), legume or bean family (Leguminosae), rose family (Rosaceae), and mustard family (Cruciferae). The species of plants show a distinctly eastern geographic relationship. In addition, a number of species are intro-

FIGURE 2-17



VEGETATION MAP OF THE OTTUMWA SITE

duced or alien, often in the same case occupying a "weedy" role in the ecology of the site.

2.0722 Gallery forest

a. The gallery forest is found along the banks of the Des Moines River and Avery Creek, and in the unplowed moist lowlands of the river flood plain. The gallery forest that remains is only a small, much disturbed remnant of the original; the older trees (silver maple and cottonwood) are between 30 and 40 years old. At least 32 families of vascular plants are present in this forest type.

b. Expressed as per cent of the canopy cover, the tree canopy in the gallery forest is characterized by box elder (*Acer negundo*) 30 per cent, silver maple (*Acer saccharinum*) 27 per cent, cottonwood (*Populus deltoides*) 18 per cent, and green ash (*Fraxinus pennsylvanica*) 10 per cent. The remaining 15 per cent is scattered among several other species: red elm (*Ulmus rubra*), American elm (*Ulmus americana*), honey locust (*Gleditsia triacanthos*), hackberry (*Celtis occidentalis*), willow (*Salix* spp., mostly *S. nigra* and *S. interior*), black walnut (*Juglans nigra*), and red mulberry (*Morus rubra*). Box elder, silver maple, and green ash show a wide range of sizes, indicating successful reproduction of these species. Cottonwood is found only in the larger size classes, indicating that it requires some form of disturbance (probably flooding) for its reproduction. Except for a few oaks on the uplands, the largest trees on the site are found in the gallery forest. Some individuals of both silver maple and cottonwood have diameters greater than 60 cm, and heights over 30 m. Tree density in young forests may reach 700-800 per hectare (ha), dropping to 400-500 per ha with maturity.

c. The most abundant shrub species in the gallery forest is poison ivy (*Rhus radicans*). Other shrubs include elderberry (*Sambucus canadensis*) and gooseberry (*Ribes* sp.).

d. Several species of herbs are very common on the floor of the gallery forest. However, these species do not occur uniformly, but rather are found in extensive, dense stands in some areas, and only occasionally in others. The most likely explanation for this is the different disturbance histories of the different parts of the gallery forest. The very abundant herbs are: stinging nettle (*Laportea canadensis*, bedstraw (*Galium aparine*), daisy fleabane (*Erigeron strigosus*), Virginia waterleaf (*Hydrophyllum virginianum*), jewel-weed (*Impatiens pallida*) and, following the drying of floodwaters, clearweed (*Pilea pumila*).

e. Other herb species found in the gallery forest, but in lower abundances include: *Ambrosia trifida*, Arabis *shortii*, *Arctium* sp., *Aster pilosa*, *Bidens* sp., *Carex* spp., *Cirsium discolor*, *Convolvulus* sp., Conyza canadensis, Dactylis glomerata, Fragaria sp., Lactuca sp., Melilotus officinale, M. alba, Menispermum canadense, Mirabilis nyctaginea, Oxalis europea, Parthenocissus vitacea, Phlox divaricata, Plantago sp., Poa pratensis, Polygonatum biflorum, Polygonum sp., Ranunculus abortivus, Scutellaria sp., Silphium perfoliatum, Smilax hispida, Taraxacum officinale, Thalictrum dioicum, Urtica dioica, Viola sp., and Vitis riparia. In addition, there are a number of species of grasses and a few forbs that are unidentifiable without complete flowers, which were unavailable at the time of collection.

2.0723 Pond-edge woods.

a. This vegetation type, on the Ottumwa Site, is found around the crescent-shaped pond (probably an old ox-bow)near the intersection of the county road and the Burlington Northern Railroad tracks. A small piece is also found at the back (south) of a small farm pond near the western end of the site. The woods are located in habitats that are very moist throughout the year. They may occasionally be under shallow water for brief periods.

b. Generally, this vegetation is younger and more dense than that of the gallery forest. The species composition of the shrub and herb layers is similar to the gallery forest, except in the pond-edge woods a large amount of snowberry (Symphoricarpus sp.) is found in the shrub component. The main difference between the gallery forest and the pond-edge woods is in the tree canopy. In the pond-edge woods, willows, especially black (Salix nigra) and sandbar (S. interior) are very common. Also, river birch (Betula nigra) is present. Other species present in relatively small amounts include American elm (Ulmus americana), black walnut (Juglans nigra), box elder (Acer negundo) red mulberry (Morus rubra), white ash (Fraxinus americana), and honey locust (Gleditsia triacanthos).

2.0724 Successional upland forest.

a. The successional upland forest is a regrowth woods found wherever the land had once been disturbed by plowing, pasture or severe cutting, and is now left alone. On the Ottumwa Site, this vegetation may be bound along the old railroad right-of-way especially where it nears Avery Creek. This type also occurs in abandoned pastures and in most of the unplowed drainage-ways that have become wooded. The growth of this forest is very dense and vigorous, characterized by young trees and a relatively high diversity of species. Twenty-five families of plants have been collected here.

b. The tree layer contains a number of species, of which four, about equally abundant, are generally the most important, occupying about

80 per cent of the canopy cover: bur oak (*Quercus macrocarpa*), shingle oak (*Q. imbricaria*), honey locust (*Gleditsia triacanthos*) and very large cottonwoods (*Populus deltoides*). Other scattered species include American elm (*Ulmus americana*), shagbark hickory (*Carya ovata*), chinkapin oak (*Quercus muhlenbergii*), black cherry (*Prunus serotina*), hackberry (*Celtis occidentalis*), willows (*Salix interior*, *S. eriocephala*), and black locust (*Robinia pseudoacacia*).

c. The shrub layer is very diverse and very dense, with no obvious dominance by any species. Found in the shrub layer are the following species: staghorn sumac (*Rhus typhina*), wild rose (*Rosa suffolta*), blackberry (*Rubus* sp.), dogwood (*Cornus stolonifera*), honeysuckle (*Lonicera* sp.), snowberry (*Symphoricarpus* sp.), poison ivy (*Rhus radicans*), small ashes (*Fraxinus* sp.), smooth sumac (*Rhus glabra*), small red mulberry (*Morus rubra*), and prickly ash (*Xanthoxyllum americana*).

d. The herb layer in the successional upland woods is very dense. As is true for the shrubs, no single species dominates the herb layer. Rather, the many species occur in diverse groups. Species found in the herb layer at one place or another are: *Allium* sp., *Ambrosia artemisifolia*, *Amphicarpa bracteata*, *Anemone canadensis*, *Asparagus officinalis*, *Aster pilosa*, *A. nova-angliae*, *Botrychium virginiana*, *Bromus tectorum*, *Campanula americana*, *Carex* sp., *Cassia fasicularis*, *Convolvulus sepium*, *Conyza canadensis*, *Dactylis glomerata*, *Erigeron strigosus*, *Fragaria* sp., *Galium aparine*, *G. triflorum*, *Lactuca* sp., *Melilotus alba*, *M. officinale*, *Monarda fistulosa*, *Muhlenbergia* sp., *Oenothera biennis*, *Oxalis europea*, *Parthenocissus quinquefolia*, *Poa pratensis*, *Ratibida pinnata*, *Silphium perfoliatum*, *Stachys tenuifolia*, *Taraxacum officinale*, *Teucrium canadense*, *Trifolium pratense*, *T. repens*, *Vicia americana*, *Viola* sp., *Vitis riparia*, and a number of others.

2.0725 Upland oak forest.

a. This vegetation is found in small pieces and long thin strips on the steeper slopes, and along the high slopes above Avery Creek on the western portion of the Ottumwa Site. The forest is characterized by very large oaks, spaced apart, with a dense understory and herb layer. These forests are the best forests on the site; although they would not be considered mature forests, they better approximate the undisturbed condition than any of the forests on the Ottumwa Site. Their age structure and species composition indicate that these forests have been disturbed primarily by cutting and perhaps some grazing, rather than by clearing and/or plowing. There are at least 26 plant families in this vegetation.

b. The upland oak forests are dominated by white oak (*Quercus alba*), which occupies about 50-60 per cent of the canopy cover. Other oaks sharing about 20 per cent of the cover include bur oak (*Q. macrocarpa*), red oak (*Q. rubra*), and black oak (*Q. velutina*). Other species present in small amounts and scattered individuals are: basswood (*Tilia americana*), shagbark hickory (*Carya ovata*), black cherry (*Purnus serotina*), ironwood (*Ostrya virginiana*), hackberry (*Celtis occidentalis*), river birch (*Betula nigra*) and hawthorne (*Crataegus* sp.).

c. The density of canopy trees is about 300-400 per hectare. The largest trees are white oak, which reaches almost one meter in diameter at breast height (1.5 m). The other oaks are also relatively large, ranging up to .75 m in diameter. The hickories are about 30 cm in diameter.

d. The shrub layer is very dense, and the thorn species make it very difficult to traverse. The most common shrub species are gooseberry (*Ribes missouriense*), honeysuckle (*Lonicera* sp.) and poison ivy (*Rhus radicans*). Other species in the shrub layer include: small shingle oaks (*Quercus imbricaria*), small box elders (*Acer negundo*), wild rose (*Rosa* sp.), small elms (*Ulmus* sp.), *Viburnum rafinesqueianum*, and choke cherry (*Prununs virginiana*).

e. The common herbs found in the upland oak forest are listed below. Some of these are true forest herbs, while some are species expected in more open areas, and occur in the oak forest primarily along the edges of the more open slopes above Avery Creek. The most abundant species are enchanter's nightshade (*Circaea quadrisculata*), Virginia waterleaf (*Hydrophyllum virginianum*) and Virginia creeper (*Parthenocissus vitacea*). Other common species are: *Achillea millefolium*, *Ambrosia artemisifolia*, *A. trifida*, *Amorpha canescens*, *Bromus inermis*, *Carex* spp., *Cirsium* sp., *Dactylis glomerata*, *Erigeron strigosus*, *Galium aparine*, *Impatiens* sp., *Parthenocissus quinquefolia*, *Penstamon tubaeflorum*, *Phlox divaricata*, *Poa pratensis*, *Podophyllum peltatum*, *Polygonatum biflorum*, *Potentilla simplex*, *P.* sp., *Ranunculus abortivus*, *Sanicula gregaria*, *Smilax herbacea*, *Solidago* sp., *Trifolium pratense*, *T. repens*, *Viola* sp., *Vitis riparia*, *Woodsia obtusa*, and *Xanthium* sp.

2.0726 Fencerows and field edges.

a. This vegetation type is located throughout the Ottumwa Site where fences and field edges escape cultivation, and pasture edges escape grazing. There is a dense herbaceous vegetation along these edges, but because of their relative inaccessibility, there are also scattered trees and occasional shrubs, the woody species covering perhaps 5-10 per cent of the ground surface. The scattered tree species include: black cherry (*Prunus serotina*), honey locust (*Gleditsia triacanthos*), black walnut (*Juglans nigra*), American elm (*Ulmus americana*), apple (*Pyrus ioensis*), hawthorn (*Crataegus* sp.), shingle oak (*Quercus imbricaria*), plum (*Prunus americana*) and red mulberry (*Morus rubra*). The scattered shrub species include: small hackberries (*Celtis occidentalis*), staghorn sumac (*Rhus typhina*), honeysuckle (*Lonicera* sp.), elderberry (*Sambucus canadensis*), poison ivy (*Rhus radicans*), and blackberry (*Rubus* sp.). At least 26 families of plants exist in this type.

b. The herbaceous edges of the fields are more-or-less zoned. Foxtails (*Setaria faberi*, *S. lutescens* and *S. viridis*) grow in the plowed soil, little ragweed (*Ambrosia artemisifolia*) is found along the immediate edge, dense stands of sweet clover (both white, *Melilotus alba*, and yellow, *M. officinale*) are found inward from the ragweed zone, and finally, in the center are found the mixed species of the fencerow proper. The most common of these latter fencerow and edge species are: smooth brome grass (*Bromus inermis*), orchard grass (*Dactylis glomerata*), bedstraw (*Galium aparine*), bluegrass (*Poa pratensis*) and wild grape (*Vitis riparia*). Other species include: *Achillea millefolium*, *Ambrosia trifida*, *Asclepias syriaca*, *Barbarea vulgaris*, *Bidens* spp., *Bromus tectorum*, *Campanula americana*, *Capsella bursa-pastoris*, *Carex* spp., *Cassia fasicularis*, *Chenopodium album*, *Cirsium discolor*, *Convolvulus arvensis*, *Conyza canadensis*, *Daucus carota*, *Echinocloa* sp., *Elymus canadensis*, *Erigeron annus*, *E. strigosus*, *Hordeum jubatum*, *Ipomea hederacea*, *Lactuca* sp., *Leonurus cardarica*, *Lepidium densiflorum*, *Lychnis alba*, *Medicago sativa*, *Monarda fistulosa*, *Oxalis europea*, *Parthenocissus vitacea*, *Plantago major*, *Polygonum persicaria*, *P.* sp., *Potentilla recta*, *Ratibida pinnata*, *Rorippa* sp., *Rumex crispus*, *Sisymbrium officinale*, *Solanum carolinese*, *S. nigrum*, *Sorghastrum nutans*, *Stachys tenuifolia*, *Taraxacum officinale*, *Teucrium canadense*, *Trifolium pratense*, *T. repens*, and several others.

2.0727 Old fields.

a. Old fields are areas that at one time had been cleared or plowed, but now are abandoned and returning to a more-or-less natural vegetation. On the Ottumwa Site, old fields are located along a swale in the westernmost section, around farm ponds, and along the Burlington Northern right-of-way where it diverges from the old railroad bed near the east end of the site. This vegetation is almost entirely composed of herbaceous species; there are a few scattered shrub-size tree species, primarily black cherry (*Prunus serotina*) and elms (*Ulmus* sp.), and a few scattered shrubs: dogwood (*Cornus stolonifera*), honeysuckle (*Lonicera* sp.) and wild rose (*Rosa suffolta*). Twenty-one plant families have been identified in the old fields.

b. The herbaceous component of the old field is the characteristic feature of the vegetation. Since old fields are abandoned, they usually are composed of species that in an ecological sense are early successional, and are often considered "weedy". The most common herbaceous species include smooth brome grass (*Bromus inermis*), wild carrot (*Daucus carota*), bedstraw (*Galium aparine*), bluegrass (*Poa pratensis*), goldenrods (*Solidago canadensis*, *S. nemoralis*) and wild grape (*Vitis riparia*).

c. Other species usually found in old fields include: *Abutilon theophrastes*, *Ambrosia artemisifolia*, *A. trifida*, *Anthemis arvensis*, *Asclepias syriaca*, *A. verticillata*, *Aster pilosa*, *A. nova-angliae*, *Barbarea vulgaris*, *Bromus tectorum*, *Carex* sp., *Chenopodium album*, *Cirsium* spp., *Convolvulus* sp., *Conyza canadensis*, *Echinocloa* spp., *Elymus canadensis*, *Erigeron strigosus*, *Hordeum jubatum*, *Lactuca* sp., *Lepidium densiflorum*, *Melilotus alba*, *M. officinale*, *Phleum pratense*, *Plantago* sp., *Polygonum pennsylvanica*, *P. persicaria*, *Potentilla recta*, *Oxalis europea*, *Rumex* sp., *Sisymbrium officinale*, *Sorghastrum nutans*, *Taraxacum officinale*, *Trifolium pratense*, *T. repens*, *Verbena stricta*, *V. urticifolia*, and several others.

2.0728 Roadsides and railroad rights-of-way.

a. A vegetation which has a similar species composition to that of the old-field, but which has a significantly different appearance because of strong dominance by smooth bromegrass (*Bromus inermis*), exists along the county road and the Burlington Northern Railroad tracks. These areas were planted to smooth bromegrass following construction activity. Since then, a number of species (at least 30 families) have invaded, including a few small trees and shrubs, but the dominant aspect is one of planted grasses. In addition to smooth bromegrass, white and yellow sweet clover (*Melilotus alba*, *M. officinale*) and red clover, (*Trifolium pratense*) are common in this vegetation type. The very scattered woody species include small trees (juniper, *Juniperus virginiana*; elm, *Ulmus* sp.; box elder, *Acer negundo*; black cherry, *Prunus serotina*; red mulberry, *Morus rubra*; bur oak, *Quercus macrocarpa* and scattered shrubs (elderberry, *Sambucus canadensis*; poison ivy, *Rhus radicans*; gooseberry, *Ribes missouriense*; dogwood, *Cornus* sp.; blackberry, *Rubus* sp.).

b. Other species of herbaceous plants found in the roadsides are also commonly found in one or more of the other vegetation types. Common roadside species include: *Abutilon theophrastes*, *Ambrosia artemisifolia*, *A. trifida*, *Anemone canadensis*, *Asclepias syriaca*, *A. verticillata*, *Campanula americana*, *Cardaria draba*, *Carex* spp., *Cichorum intybus*, *Cirsium discolor*, *Conium maculatum*, *Convolvulus*, sp., *Dactylis glomerata*, *Daucus carota*, *Elymus canadensis*, *Equisetum arvense*, *Erigeron annus*, *E. strigosus*, *Hordeum jubatum*, *Lactuca* sp., *Medicago sativa*, *Oenothera biennis*, *Oxalis europea*, *Parthenocissus* vitacea, Pastinaca sativa, Phleum pratense, Plantago major, Poa pratensis, Rorippa islandica, Rumex crispus, Solanum carolinense, Taraxacum officinale, Trifolium procumbens, T. repens, Verbena stricta, V. urticifolia, Viola sp., Vitis riparia and a number of others.

2.0729 Wet grasslands.

a. The wet grasslands of the Ottumwa Site are found as extensions of any of the main grassland vegetations into habitats where soil moisture remains high throughout the year. Often there may be standing water in the spring, or following a heavy rain. In these habitats, some of the upland species of grassland plants are not successful, whereas several additional species grow luxuriantly. Normally, the number of species growing in wet grasslands is lower than that for adjacent upland areas. Species which are particularly characteristic of wet grasslands include several species of sedges (Carex spp.), rushes (Juncus spp.), bulrushes (Scirpus atrovirens, S. sp.) and horsetail (Equisetum sp.).

2.073 Agriculture

2.0731 Of the Ottumwa Site, most of the acreage, is in agricultural production. During the 1975 season, approximately 301 acres were planted to corn, 147 acres to soybeans, 88 acres were in hay and 259 acres were in pasture. Farm buildings, roads, etc. account for additional acreage. The row-crop fields are annually tilled, although occasional seasons are so wet that tillage in the bottoms is impeded.

2.0732 If the amount of cropland on each soil type for the 1975 season, as determined by field visit, is multiplied by the estimated crop yields according to the U.S. Soil Conservation Service[1], the following crop values are expected: $94,080 of corn, $26,520 for soybeans, $2,640 for hay, and $2,590 for rough pasture for a total of $125,830. These estimates are based on a value of $420/acre for corn; $260/acre for soybeans; $30/acre for hay meadow; and a grazing value of $10/acre for the remaining acreage. The gross value, rounded off, of farm produce from the Ottumwa Site is about $126,000 per year. The average expected corn and bean yields are about the same as, or slighlty lower than, the average yield for the State of Iowa, given annual fluctuations.

2.074 Mammals

2.0741 General. The 34 species of terrestrial mammals observed or expected on the Ottumwa Site are shown in Appendix C, Table C-1. Notes were made during Summer and Fall 1975 on large game and other mammals, and standard North America census lines were run three times in the various vegetation types. In general, the mammalian fauna is not particularly diverse, and is much a reflection of the mammals of Iowa. That is, there is little that characterizes the mammals of the site that is not also characteristic of the Iowa mammals in general. Since there is a mixture of several habitats on the site, a relatively large percentage of the total mammalian fauna of Iowa is found or expected in the area. Most of the mammalian species on the site are geographically eastern, or most of the conterminous U.S.

2.0742 Game mammals. The important game mammals on the Ottumwa Site are the cottontail rabbit (Silvilagus floridanus), fox squirrel (Sciurus niger), gray squirrel (Sciurus carolinensis; expected), muskrat (Ondatra zibethica), raccoon (Procyon lotor), red fox (Vulpes fulva), mink (Mustela vison; expected), and white-tailed deer (Odocoileus virginiana). The muskrat and mink are usually trapped, while the others are usually shot. The cottontail rabbit is one of the most common animals on the site, and undoubtedly is an often-hunted mammal. Squirrels, especially the fox squirrel are also abundant, and hunter presence during Fall 1975 indicates that it is an important game species. Muskrat burrows were common along the Des Moines River banks, and probably some exist in the various ponds of the area. No trapping success is known for this species. No mink results are known as well; this species was not seen, but its presence is expected. Raccoon sign was very abundant anywhere near water, indicating an abundance of this species. Fox sign was more rarely encountered, but the habitat is very appropriate, and a relatively high population level is expected. Several deer were seen during 1975, including young, indicating that the species reproduces in the area. Residents mention that several deer are taken every year. In general, the availability of fields, forest, very abundant edge habitat, and water makes the Ottumwa Site a good game mammal area, compared with the State of Iowa as a whole.

2.0743 Other large mammals. Of the large non-game mammals, opossum (Didelphus marsupialis) and striped skunk (Mephitis mephitis) are the most common on the Ottumwa Site. Others seen include the woodchuck (Marmota monax) and pocket gopher (Geomys bursarius).

2.0744 Small mammals.

a. A number of standard North American census lines for small mammals were run in several of the major habitats on the Ottumwa Site. Several species were captured, in some cases with enough abundance to obtain good estimates of population health. Species captured are given below by habitat. No traps were set in the pond-edge woods, since this habitat is so small and scattered that sufficient trapping could not be done.

b. Gallery forest. The most abundant small mammal, by far, in the gallery forest is the white-footed mouse (Peromyscus leucopus). A total of 84 were captured, this being about 15.6 per cent of all the traps set in this habitat. Other small mammals in this habitat include the short-tailed shrew (Blarina brevicauda) of which 7 were captured, and the masked shrew (Sorex cinereus) of which only one was caught. The total catch of small mammals in this habitat was greater, both as totals and as percentages, than any other habitat investigated. About 53 per cent of all small mammals were trapped in the gallery forest.

c. Upland successional woods. The only small mammals species captured in this habitat were two species of Peromyscus, P. leucopus (white-footed mouse) and P. maniculatus (deer mouse). Population levels were not high (2.3 per 100 trap-nights), and the number of species caught was unexpectedly low.

d. Oak woods. The only small mammal species collected in the oak woods was the white-footed mouse (Peromyscus leucopus). This species was captured at a rate of 6 per 100 trap-nights, not an unusual population size for this type of habitat.

e. Fencerows and edges. Small mammals were captured at a rate of about 6 per 100 trap-nights in the fencerow and edge vegetation type. As in the other grassland types, the diversity of species was greater than in the forests, although the abundance of any one species usually is not as high as those in the forests. Six species were captured: white-footed mouse (Peromyscus leucopus), short-tailed shrew (Blarina brevicauda), masked shrew (Sorex cinereus), meadow vole (Microtus pennsylvanicus), prairie vole (M. ochrogaster) and deer mouse (Peromyscus maniculatus). At least several of each species was captured, except that only one deer mouse and one prairie vole were trapped. The first three species were captured throughout the summer and fall, but the meadow vole was only captured in the October sampling. No explanation is known for this, although this species is known to fluctuate greatly, and it may be that it is just beginning to return to the expected high density levels.

f. Old fields. Old fields also yield a number of species (four) of small mammals but with a relatively low population level. The species caught were the white-footed mouse (Peromyscus leucopus), short-tailed shrew (Blarina brevicauda), masked shrew (Sorex cinereus) and meadow vole (Microtus pennsylvanicus). Small mammals were caught at a rate of about 6 per 100 trap-nights in this habitat.

g. Roadsides. The roadside habitat has a high diversity of small mammals. Seven species were captured here, although the overall density of all species combined was not particularly high (7.4 per

100 trap-nights). Species found were white-footed mouse (Peromyscus leucopus), short-tailed shrew (Blarina brevicauda), house mouse (Mus musculus), masked shrew (Sorex cinereus), meadow jumping mouse (Zapus hudsonius), meadow vole (Microtus pennsylvanicus), and the deer mouse (Peromyscus maniculatus). The most abundant species were the white-footed mouse and the shrews.

h. Species population levels. The number of individuals of each species of small mammals captured on the Ottumwa Site are shown in Table 2-20. The total catch occurred at a rate of 8.8 per 100 trap-nights; this would be a moderate abundance level of small mammals. The greatest seasonal abundance was during August, when 14.0 small mammals were caught per 100 trap-nights, compared with 7.7 per 100 in June and 6.4 per 100 in October. Population changes in Peromyscus leucopus, the white-footed mouse, account for most of the seasonal variation. The population of the white-footed mouse appears to be healthy. There were 8 pregnant and 7 lactating females, indicating successful reproduction, as well as a range of ages. The average litter size was 4.14. The ratio of males to females in this species was 1.24; often a larger number of males is caught, presumably because of a larger home range than for the females. The population of short-tailed shrews appeared quite substantial (27 caught, 1.4 per 100 trap-nights), but the population lacks evident reproduction. Often, the levels of this species are inversely related to that of the voles (Microtus pennsylvanicus and M. ochrogaster), because the shrews prey on the voles, especially the nestlings. Since the short-tailed shrew population shows no reproduction, and the vole population shows signs of increasing (e.g., no catch during June or August, all caught in October), it may be expected that the shrew population will decrease. Three of the meadow vole females were pregnant, averaging 7.0 young per litter. Both the short-tailed shrew and the masked shrew (Sorex cinereus) had a preponderance of females in the population (sex ratio for Blarina was 0.24; for Sorex it was 0.18). One pregnant masked shrew was found. The other species did not have high enough returns in the traps for adequate estimates of population conditions.

2.075 Birds

2.0751 General. Bird species seen or suspected for the Ottumwa Site are listed in Appendix C, Table C-2. More birds were not seen primarily because field work commenced after the major spring migration was finished. There are a number of birds recorded for Iowa which are known to be accidentals or wanderers from normal ranges. These are not listed in Appendix C; Brown (1971)[2] may be consulted for these species.

2.0752 Breeding birds. A number of species of birds, other than game and raptorial birds, were seen nesting, heard singing, or noted

Table 2-20

NUMBERS AND CATCH PER 100 TRAP-NIGHTS OF SMALL MAMMALS ON THE OTTUMWA SITE, JUNE-OCTOBER 1975

Species	No. Caught	Individuals per 100 Trap-nights
White-footed mouse (Peromyscus leucopus)	114	5.8
Short-tailed shrew (Blarina brevicauda)	27	1.4
Masked shrew (Sorex cinereus)	15	0.8
Meadow vole (Microtus pennsylvanicus)	8	0.4
Deer mouse (Peromyscus maniculatus)	6	0.3
House mouse (Mus musculus)	1	0.05
Meadow jumping mouse (Zapus hudsonius)	1	0.05
Prairie vole (Microtus ochrogaster)	1	0.05
TOTAL	173	8.85

in a manner that indicated a breeding population on the site. These breeding birds include: killdeer (*Charadrius vociferus*), mourning dove (*Colaptes macrura*), belted kingfisher (*Magaceryle alcyon*), flicker (*Colaptes auratus*), red-bellied woodpecker (*Centurus carolinus*), red-headed woodpecker (*Melanerpes erythrocephalus*), hairy woodpecker (*Dendropus villosus*), downy woodpecker (*Dendrocopus pubescens*), eastern kingbird (*Tyrannus tyrannus*), eastern phoebe (*Sayornis phoebe*), bank swallow (*Riparia riparia*), barn swallow (*Hirundo rustica*), purple martin (*Progne subis*), bluejay (*Cyanocitta cristata*), common crow (*Corvus brachyrhynchos*), black-capped chickadee (*Parus atricapillus*), tufted titmouse (*Parus bicolor*), white-breasted nuthatch (*Sitta carolinensis*), house wren (*Troglodytes aedon*), catbird (*Dumetella carolinensis*), brown thrasher (*Toxostoma rufum*), robin (*Turdus migratorius*), wood thrush (*Hylocichla mustelina*), starling (*Sturna vulgaris*), yellowthroat (*Geothlyptis trichas*), house sparrow (*Passer domesticus*), eastern meadowlark (*Stunella magna*), red-winged blackbird (*Agelaius phoeniceus*), Baltimore oriole (*Icterus galbula*), common grackle (*Quiscalus quiscala*), brown-headed cowbird (*Molothrus ater*), cardinal (*Richmondena cardinalis*), rose-breasted grosbeak (*Pheucticus ludovicianus*), indigo bunting (*Passerina cyanea*), dickcissel (*Spiza americana*), American goldfinch (*Spinus tristis*), rufous-sided towhee (*Pipilo erythropthalmus*), grasshopper sparrow (*Ammodramus savannarum*), chipping sparrow (*Spizella passerina*), field sparrow (*Spizella pusilla*), and song sparrow (*Melospiza melodia*).

2.0753 *Feeding and/or roosting birds of prey*. Several species of Raptors were noted feeding or roosting on the site. Roosting birds include the great-horned owl (*Bubo virginianus*) and the red-tailed hawk (*Buteo jamaicensis*). Raptors seen feeding or soaring above the site include: turkey vulture (*Cathartes aura*), great-horned owl, red-tailed hawk, and harrier (*Circus cyaneus*). Other hawks, such as the broad-winged hawk, are expected feeders on the site. Of the larger wading birds, the great blue heron (*Ardea herodias*) and the green heron (*Butorides virescens*) were seen feeding, mostly in the Des Moines River.

2.0754 *Game birds*. Resident upland game birds that are commonly seen include the ring-necked pheasant (*Phasianus colchicus*) and the bobwhite quail (*Colinus virginianus*). A number of migratory game birds, especially the puddle ducks (mallard, *Anas platyrhychos*, blue-winged teal, *Anas discors*, for example) and the Canada goose (*Branta canadensis*) are expected on the site during the migration seasons.

2.0755 *Rare birds*. The only rare and endangered species noted on the site was an Osprey (*Pandion haliaetus*) most likely migrating through along the Des Moines River. There is no evidence of breeding or roosting by this species on the site. If the bird is, in fact, migrating through, then the impact of the project will be limited to local disruption which may cause migrating ospreys to go several kilometers out of the usual route. Bald eagles (*Haliaeetus leucocephalus*) have been seen in the past along the Des Moines River during migration. The project impact on this species is likely to be the same as for the osprey.

2.076 *Herptiles*. The species of amphibians likely to occur on or near the Ottumwa Site are shown in Appendix C, Table C-3. Similarly, reptiles are shown in Appendix C, Table C-4. These tables were constructed primarily from the literature available (which is minimal)[3,4]. No attempt was made to systematically search the site for herptiles. Those seen in the course of other field work include the more common amphibians: American toad (*Bufo americana*), treefrog (*Hyla versicolor*), green frog (*Rana clamitans*) and bullfrog (*Rana cataesbiana*). Snapping turtles (*Chelydra serpentina*) and other turtles (unidentified) were also seen. Several garter snakes (*Thamnophis sirtalis* and *T. radix*) were observed. The project impact on this component of the fauna of the Ottumwa Site is limited to elimination of habitat, especially ponds and riparian forest, which will reduce the local populations of herptiles.

2.077 *Insects and Other Invertebrates*.

2.0771 *Insects*

a. A wide range of insect types is found on the Ottumwa Site. A comparative set of sweep samples were obtained from several different grass and edge habitats. The edge habitat showed a high diversity of species, and a high density of insects. Hayfields and fencerows show a lower abundance of both species and numbers of individuals, while the roadsides along the county highway are the poorest in insects. The edge also shows a greater abundance of insects in that fraction which is not sampled by sweep nets; both flying and crawling insects were very abundant. Some of the more common insect groups include: ants (very abundant, and very noticeable on the bait of the small mammal traps); bees and wasps, both solitary and colonial; butterflies and moths; grasshoppers and crickets; leaf hoppers; true bugs; flies; aphids; dragonflies and damselflies, and numerous scavenging and predatory beetles.

b. A number of human insect pests (non-agricultural) were noted. Field personnel can vouch for the abundance of ticks, tabanid and other biting flies, and mosquitoes.

2.0772 Spiders. Spiders are also very abundant on the Ottumwa Site. Several species of harvestmen (grand-daddy long-legs) are abundant, often seen on the small mammal traps. Other spiders include the crab spiders, jumping spiders, wolf spiders and others. All these are predators; in fact, spiders, along with predatory beetles, are likely the most abundant and most important of the predaceous fauna of the litter layer and soil.

2.0773 Other invertebrates. The most common of the macroscopic invertebrates are the following groups: earthworms (Annelida; Oligocaeta) in the soils, snails and slugs (Molluska; Gastropoda) in the litter and moist places, sowbugs (Crustacea; Isopoda) most everywhere, crayfish (Crustacea; Decapoda) near ponds and river banks, and millepedes (Diplopoda) and centipedes (Chilopoda) were common under logs, in the litter, etc.

2.078 Succession and Ecosystem Function.

2.0781 Succession.

a. The process of succession is the gradual replacement of colonizing organisms with those of longer life-spans (for the dominant species) and better competitive abilities. Normally, in the absence of fire and with enough precipitation, a plowed or cleared area will pass through several herb, grass, shrub and tree stages, ultimately reaching a relatively stable endpoint which lasts substantially longer than the earlier stages. This last stage would be a forest. In much of Iowa previous to white settlement, there were many natural fires which tended to make the successional sequence develop into complex and rich prairies rather than forest.

b. The Ottumwa Site was covered by both forest and prairie before settlement. The forests extended over the flood plain and up the more mesic slopes, while prairie covered the drier uplands. Presently, there are few traces of this original vegetation. Some of the characteristics of the present gallery forest are similar to those of the pristine forest (i.e., some species, the high abundance of nettles, etc.), and there are a few native prairie species scattered around the site, but there is no truly native vegetation (as opposed to native species).

c. The only areas for which the successional processes can be described are those which are not under cultivation, since cultivation, as long as it occurs, prevents succession. (Indeed, it can be said that the ecological purpose of cultivation is to prevent succession.) In the forested areas, the gallery forest is presently developing toward a true flood plain forest, the oak woods is developing toward a mesic deciduous forest and the secondary succession woods will become oak forests. All this assumes that these areas would be left alone, so that succession could follow normal paths. However, these areas receive great impact from the cultivated fields (e.g., nutrient runoff), are now protected from flooding which is a natural ingredient in the native environment, and, since they are in private ownership, are not protected from disturbance by cutting for the more valuable timber (e.g. black walnut, white oak, etc.). Therefore, it is unreasonable to predict that these forests will eventually evolve into anything resembling native vegetation, since the forests are not in a condition now, nor would they be in the future, under which normal succession would progress.

d. The grasslands of the site would succeed to forest in the absence of burning, or to something resembling native prairie (although, in the absence of suitable seed sources, true native prairie would be unlikely) if burning were allowed (or undertaken). These areas would eventually become shrubby, and then trees like those of the secondary successional forest, and finally oaks and mesic forest trees would dominate. However, most of the grasslands are grazed, mowed or sprayed, and these activities tend to prevent the mature grassland species and the woody plants from entering, thereby maintaining the earlier weedy stages. It is expected, then, in light of ongoing disturbance by human activities, that the processes of ecological succession on the Ottumwa Site will not work in the normal way, and that the area will continue to contain vegetation similar to that now existing.

2.0782 Ecosystem Function

a. General. There are two important aspects of ecosystem function. One is nutrient cycling, the other is productivity or energy flow. Both are difficult and time-consuming to measure; neither were quantitatively determined in the present instance. However, it is possible to make some general statements and estimates based on present environmental and biotic conditions and upon the ecological principles of energy flow and recycling.

2.0783 Nutrient cycling.

a. Nutrient cycling is the rate and amount of return of important elements, such as the common elements of agricultural fertility (nitrogen, phosphorus, and potassium) and others such as calcium, magnesium, etc. A mature and stable system normally has a high efficiency of recycling; i.e. most of the nutrients released from the biota (mostly by decomposition) are taken up and returned to living matter. A system which is leaky, that is, which tends to lose a high percentage of elements without recycling them, is considered inefficient and unstable. It is normally expected that most ecosystems, including those found in the region of the Ottumwa Site, increase the efficiency of recycling with successional development.

b. Nutrient cycling on the Ottumwa Site is estimated to be very inefficient; there is most likely a very high rate of nutrient loss from the system. This is because of the immature age of most of the vegetation, and because of the high percentage of cultivation on the site. In other words, the area is almost totally disturbed, which means that normal recycling is also totally disturbed. In addition, because of cultivation, there is a high degree of erosion from the site, causing a loss of nutrients from the soil. Fertilizers are applied to the agricultural fields, which resupply the three basic nutrients (nitrogen, phosphorus, and potassium), but this act itself creates unstable nutrient recycling, and it is also confined to only three elements, whereas vegetation requires a number of others (in lesser amounts, usually). The natural role of river flooding is to restore nutrient fertility by depositing a load of silt on the flood plain. However, when the flood plain is cultivated (and now the flooding is under human control), floods will take nutrients from the system, therefore causing a net loss. The absence of any fine litter in the gallery forests (there are large branches and trees down) indicates that the floods are removing nutrients. In the upland forests, litter accumulation is greater. In the grasslands, especially those with much smooth bromegrass (Bromus inermis), a large amount of litter accumulates, both because of slow decomposition rates in grasslands (due to aridity) and probably also spraying, which undoubtedly affects the microorganisms of decomposition. These smooth brome habitats, especially those that are sprayed, tend to be rather sterile environments for other organisms.

2.0784 Production and energy flow.

a. General. Estimating total ecological production on the Ottumwa Site is made difficult by the fact that there is precious little data for the kinds of communities found on the site, and an equal dearth of information for Iowa in general. However, by using data gathered for other areas, and by estimating differences due to climate, it is possible to make some very tentative generalizations. Primary production is defined as that amount of energy (or amount of organic matter) produced by green plants from sunlight. Secondary production is the amount of production done by animals of the higher trophic levels (herbivores, predators, etc.).

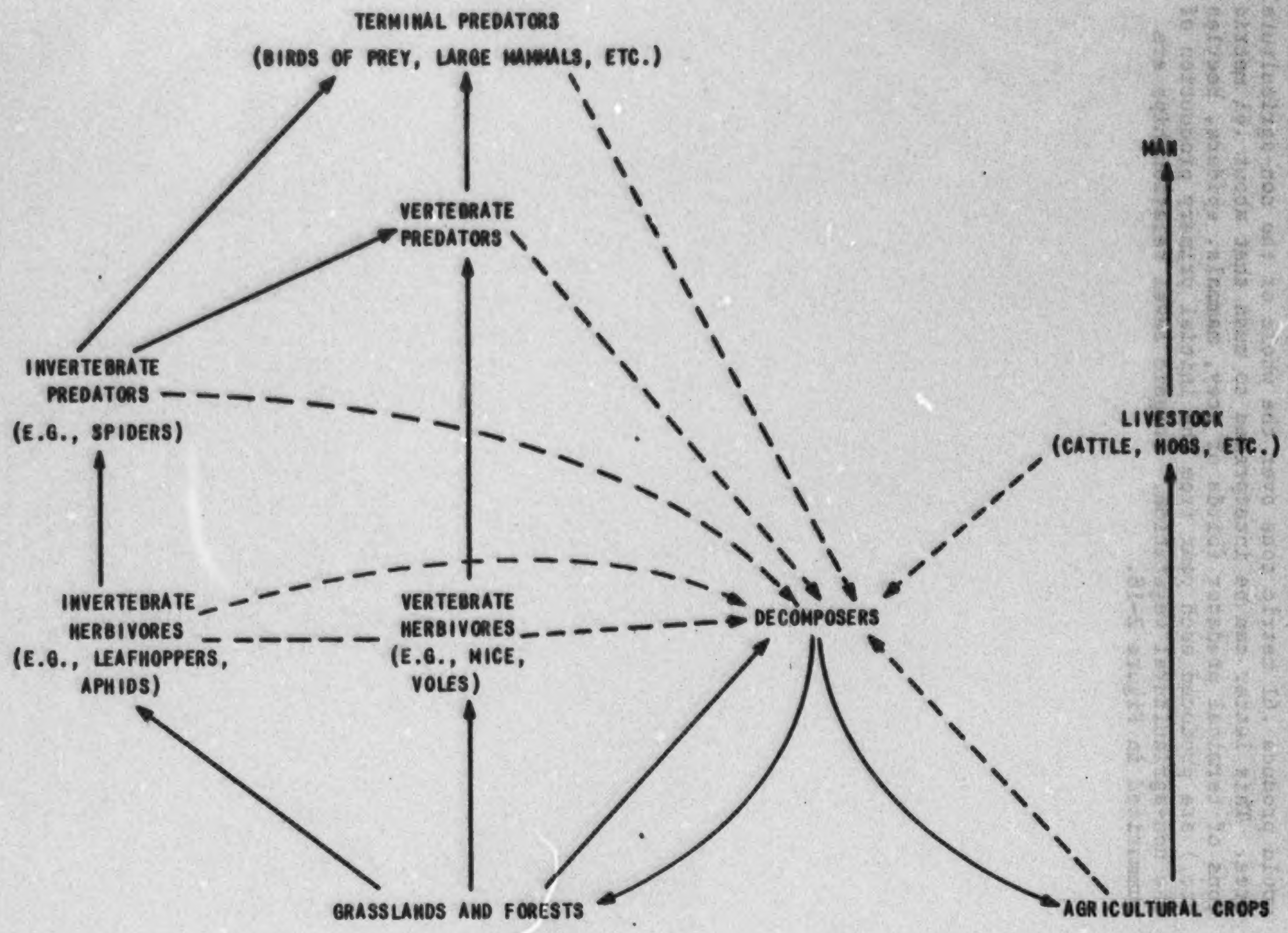
b. Agricultural. For the agricultural lands, it is possible to estimate net primary production (that which is left after respiration by the plants themselves) by converting crop yields into dry weight of organic matter, using the conversion factors of Stearns[5], and Art and Marks[6]. Using these conversions the following net primary production values are obtained (expressed as dry metric tons per hectare per year): corn 7.9, soybeans 9.6, hayfields 13.3, pasture 13.3. Multiplying by the area of each crop (from Paragraph 2.0732): corn 962 mt per year, beans 431 mt per year, hay 297 mt per year, pasture 602 mt per year. These total 2292 metric tons per year.

c. Grasslands. Primary production in grasslands varies with the type and with the climate. An average estimate is around 7 mt per hectare per year[7]. This would total 286 mt per year for all grasslands on the site.

d. Forests. This value is the most difficult to estimate. Reiners[8] measured oak forest production as 8.7 metric tons per hectare per year in Minnesota. Much of the Ottumwa Site forest is gallery forest and secondary succession upland woods, and these types would tend to have a higher growth rate than that of oak woods. If a value of 10 metric tons per hectare per year is used to account for this higher rate, then the forests of the site would yield about 324 metric tons per year.

e. Total net primary production. The total net primary production, which is the sum of agricultural land, grassland and forest, is an estimated 2902 metric tons per year, for the entire site. This would be an average of about 9.4 mt per hectare per year. Compared with other regions for which these kinds of estimates have been made, this average value is relatively high. It is substantially greater than figures for New York State[6], and compares favorably with North Carolina[9] and Wisconsin[5].

f. Secondary production. For the agricultural crops, there are two trophic levels; the herbivores and Man. For the rest of the site, there averages about three trophic levels above the vegetation (herbivores and two predator levels). A common figure used to describe secondary production of a trophic level is 10 per cent of the organic matter available from the next lower level. Thus, for the crops, 229 (10 per cent of 2292) metric tons of organic matter would be produced by herbivores (cattle and hogs, for example) and passed on to Man. For the other areas, the herbivores would yield about 61 metric tons, the next level would yield about 6.1 metric tons, and the fourth level would produce .61 metric tons over the whole of the non-agricultural area. This latter can be interpreted to mean that about .61 metric tons of terminal predator (birds of prey, mammals, spiders, beetles, etc.) are produced each year from the initial primary production of the non-agricultural vegetation. Trophic level relationships are summarized in Figure 2-18.



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2.08 Ambient Air Quality

2.081 Introduction. An assessment was made of the ambient air quality at the proposed plant site. An air sampling and meteorological station was established on the site and measurements of specific pollutants and weather parameters were made. The results of the monitoring program together with available historical data will serve as a basis for characterizing existing air quality without the Ottumwa Generating Station.

2.082 Pollutant Monitoring. A program was designed to monitor currently regulated pollutants at the proposed generating station site. Pollutants measured were suspended particulate matter, sulfur dioxide (SO_2), and nitrogen dioxide (NO_2). The concentrations of these materials are limited by both federal and state regulations.

2.083 Meteorological Monitoring. Meteorological parameters that were determined were as follows: wind direction; wind velocity; temperature; rainfall; barometric pressure; relative humidity; and cloud cover. These climatic conditions were monitored to aid the scientists at Langston Laboratories in reporting the total suspended particulate, NO_2, and SO_2 concentrations under standard conditions (25 C and 760 mm of Hg), to facilitate the interpretation of the variations in concentration for the individual air pollutants, and to enable comparisons of the data now being generated with future ambient air quality data for the area.

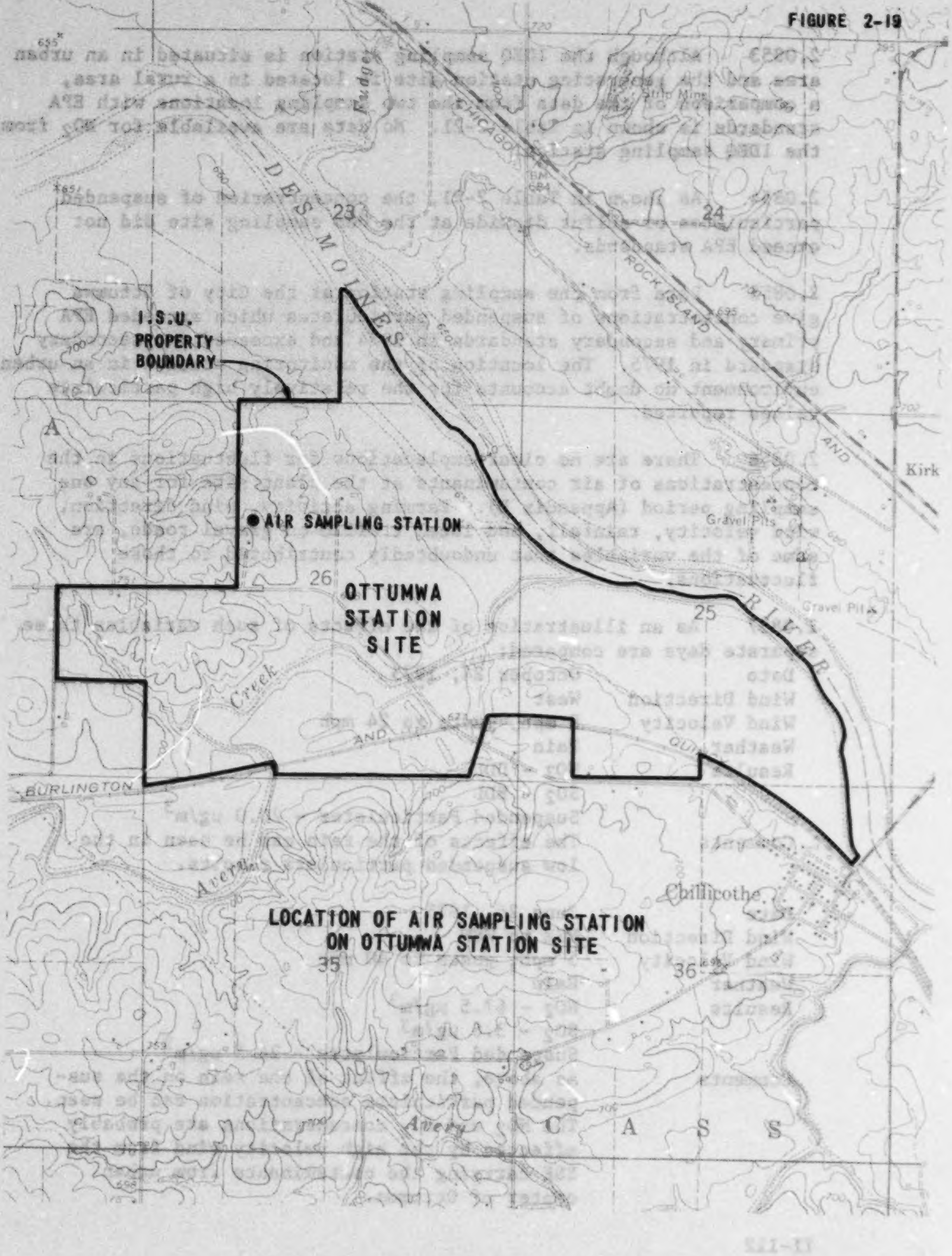
2.084 Selection of Sampling Station Site. On May 20, 1975, scientists from Langston Laboratories made a survey of the proposed plant site. A place was selected to establish an air monitoring station. In making the site selection, consideration was given to the freedom of the location from obstructions and pollution sources, availability of electricity, accessibility, security, and representativeness of the overall area. Figure 2-19 shows the location of the sampling station on the Ottumwa site.

2.085 Results. Detailed ambient air quality data from the Ottumwa site sampling station are given in Appendix D as well as the methodology employed.

2.0851 The existing ambient air quality at the proposed plant site was found to be good. During the 6-month monitoring period, the federal primary and secondary standards for suspended particulates, SO_2, and NO_2 were not exceeded on any of the sampling days.

2.0852 The nearest sampling station operated by the Iowa Department of Environmental Quality (IDEQ) is located at Ottumwa, Iowa about 8 miles southeast of the proposed generating station.

FIGURE 2-19



LOCATION OF AIR SAMPLING STATION ON OTTUMWA STATION SITE

2.0853 Although the IDEQ sampling station is situated in an urban area and the generating station site is located in a rural area, a comparison of the data from the two sampling locations with EPA standards is shown in Table 2-21. No data are available for NO_2 from the IDEQ sampling station.

2.0854 As shown in Table 2-21, the concentration of suspended particulates or sulfur dioxide at the OGS sampling site did not exceed EPA standards.

2.0855 Data from the sampling station at the City of Ottumwa give concentrations of suspended particulates which exceeded EPA primary and secondary standards in 1974 and exceeded the secondary standard in 1975. The location of the monitoring station in an urban environment no doubt accounts for the relatively high particulate values reported.

2.0856 There are no clear explanations for fluctuations in the concentrations of air contaminants at the plant site for any one sampling period (Appendix D). Farming activity, wind direction, wind velocity, rainfall, and local traffic on gravel roads, are some of the variables that undoubtedly contributed to those fluctuations.

2.0857 As an illustration of the effects of such variables three separate days are compared:

Date	October 24, 1975
Wind Direction	West
Wind Velocity	8 mph, gusts to 24 mph
Weather	Rain
Results	NO_2 - BDL SO_2 - BDL Suspended Particulates - 20.0 $\mu g/m^3$
Comments	The effects of the rain can be seen in the low suspended particulate results.

Date	June 26, 1975
Wind Direction	ESE to WSW
Wind Velocity	5 mph, gusts to 40 mph
Weather	Rain
Results	NO_2 - 67.5 $\mu g/m^3$ SO_2 - 3.6 $\mu g/m^3$ Suspended Particulates - 24.5 $\mu g/m^3$
Comments	As above, the effect of the rain on the suspended particulate concentration can be seen. The NO_2 and SO_2 concentrations are probably effected by the high velocity wind from the ESE carrying the contaminants from urban center of Ottumwa.

Table 2-21

COMPARISON OF AMBIENT AIR QUALITY DATA FROM OTTUMWA, IOWA AND THE OGS SITE WITH EPA STANDARDS

	Suspended Particulates ($\mu g/m^3$)				
	Minimum	Maximum	Geometric Mean	EPA Primary Standard	EPA Secondary Standard
IDEQ[a] 1974	19.2	313.0	79.30	260 (24-hr max.)	150
IDEQ[a] 1975	25.2	188.0	84.06		
OGS Site[b]	20.0	142.7	53.70		

	Sulfur Dioxide ($\mu g/m^3$)			
	Minimum	Maximum	Average	EPA Primary Standard[d]
IDEQ[a] 1974	BDL[c]	20.6	5.6	365 (24-hr max.)
IDEQ 1975	BDL	12.5	5.0	
OGS Site[b]	BDL	5.4	Only 3 samples greater than the minimum detectable concentration	

[a] Source: Iowa Department of Environmental Quality

[b] Source: Langston Laboratories, Inc.

[c] BDL-Below detectable limits of analytical method.

[d] No secondary standard for SO_2.

Date	July 2, 1975
Wind Direction	W to SSE
Wind Velocity	3 mph
Weather	No Rain (Clear)
Results	NO_2 - 15.5 μg/m^3 SO_2 - BDL Suspended Particulates - 142.7 μg/m^3
Comments	The effects of the dry conditions in the area can be seen in the high suspended particulate results. Farming activity, vacation and holiday traffic are also contributing factors to this, the highest suspended particulate result for the 6-month period.

2.0858 On sampling days that it rained, the suspended particulate concentration was reduced significantly. High velocity winds from the ESE resulted in increased SO_2 and NO_2 concentrations at the generating station site. The contaminants most likely were from the Ottumwa, Iowa area.

2.0859 Temperal trends in ambient air quality data are shown in Table 2-22. During the 6-month monitoring period, the highest concentration of NO_2 occurred in June. The only detectable amount of SO_2 also was reported in June. The highest concentration of suspended particulates was detected in July. The lowest amounts of NO_2 was found in August and November. From July through November, the concentration of SO_2 at the plant site was below the detectable limits of the analytical procedure used.

2.08510 The sampling station on the OGS site will continue operating until June 1976 to provide one year of base line ambient air quality data.

Table 2-22

TEMPERAL TRENDS IN AMBIENT AIR QUALITY, JUNE-NOVEMBER, 1975
(Ottumwa Generating Station Site)

($\mu g/m^3$)

Parameter	Highest 1st	2nd	3rd	4th	5th	6th	6-Month Average
NO_2	June 27.5	July 18.8	September 2.2	October 1.7	August BDL[a]	November BDL[a]	8.4
SO_2	June 2.5	July BDL[a]	August BDL[a]	September BDL[a]	October BDL[a]	November BDL[a]	-
Suspended Particulate	July 95.7	October 73.4	November 65.8	August 59.5	June 48.1	September 32.8	62.6

[a] BDL-Below detectable limits of analytical procedure.

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III RELATIONSHIP OF PROPOSED ACTION TO LAND USE PLANS

3.01 The objective of this section is to describe current land use planning goals for the area surrounding the proposed Station Site, and to discuss the compatibility of OGS with these goals.

3.02 In attempting to ascertain the extent of land use planning efforts in the proximity of OGS, several bodies which typically produce plans in such an area were contacted. These bodies included: the City of Ottumwa (the major population center in the vicinity) and Mahaska, Monroe and Wapello Counties, all of which have political jurisdiction; and the Area XV Regional Planning Commission (XVRPC) which is only an advisory body but which has the support of all the counties in Area XV. The planning documents existing in the area range from detailed zoning ordinances to generalized area wide plans.

3.021 In 1972, the City Plan and Zoning Commission of Ottumwa published a comprehensive plan that outlined general goals which they recommended as guidelines for more specific planning policies and programs. These goals are as follows.

a. To establish a pattern of land uses that will promote the highest degree of health, safety, efficiency, and well being for all segments of the community. These patterns should develop a good working relationship between land used for residences, commercial needs, industrial development and open space.

b. To establish a circulation system for the safe and efficient movement of goods and people within Ottumwa and the Ottumwa area.

c. To provide for all the necessary uses of land and services that together make a self-sustaining and self-sufficient community.

d. To create the most desirable living areas possible focusing on residential neighborhoods together with the necessary and properly located school sites, park areas, and other amenities, free from undesirable through-traffic and from the disturbances of other land uses.

e. To preserve and promote the unique and desirable character of the City of Ottumwa and to elevate the City to its fullest potential as the major urban center of Southeastern Iowa.

f. To optimize land use potentials within the City of Ottumwa.

This plan represents the most recent planning document issued by the City.

3.022 Mahaska and Monroe Counties currently have no land use planning agencies or land use plans of their own. They do, however, provide financial support for the Area XV Regional Planning Commission and rely on the planning efforts of this agency. The status of plans published by XVRPC is discussed in a subsequent subsection.

3.023 In Wapello County, the county in which OGS is to be located, a zoning ordinance as amended through March 29, 1971, provides that except for Ottumwa and the area immediately surrounding it, most of the county is zoned agricultural. The goals of this ordinance are:

a. To promote public health, safety, morals, comfort and general welfare.

b. To conserve and protect property and property values.

c. To secure and provide the social and economic advantages resulting from an orderly planned use of land resources.

d. To facilitate adequate but economical provisions for public improvements.

3.024 The proposed OGS plant site is located in a 10 county planning district in southeast Iowa known as Area XV. The Area XV Regional Planning Commission has not published formal land use plans as of this writing but such plans are expected to be available in the summer of 1977.

3.025 In August of 1975 the XVRPC published an Areawide Overall Economic Development Plan (OEDP). Area XV has been caught in a downward economic spiral for the last several years and the OEDP is the first attempt to study the entire area in sufficient depth and with adequate detail to determine the severity of the downward spiral and the best way to counter it. The goal of the OEDP is to provide a basis for planners to analyze the situation, determine the best way out of the dilemma and implement various action programs to solve the problem. Although this report is not a land use plan, it has implications for future land use in the area through the planning goals and corresponding objectives it suggests. The planning goals and objectives which the OEDP proposes are:

a. A level of growth which would insure eventual economic growth on a self-sustaining basis. This would require reestablishment of a regional population of 200,000.
Objective: Establish a balance between resource employment and new basic manufacturing job opportunities.

b. Decentralization of future economic and population growth to insure efficient use of the region's existing infrastructure, etc.
Objective: Establish one redevelopment center (Ottumwa) and three economic growth centers (Fairfield, Oskaloosa, and Centerville).

c. Coordinate development of demonstration mining and energy production projects with the Iowa Coal Project and Iowa Southern Utilities.
Objective: Provide for several demonstration projects to show how mining can contribute to industrial development and concurrently avoid environmental problems.

d. Regional improvement in the area's transportation system including: connection to Interstate Highway System, establishment of a low cost transportation system, and improvement of the rail network for shipment of farm commodities.
Objectives: (1) Promote development of Iowa Supplemental Freeway Project; (2) A regional transportation system to link isolated communities and employment centers; (3) Explore the feasibility of renovating rail lines between Northwestern and Southeastern Iowa.

e. Achieve zero unemployment rates and improve job mobility.
Objectives: (1) An effective manpower planning program; (2) Regional education systems geared to creation of skills required for the area's growth; (3) Support for programs to insure that hard core unemployed will have potential for long-term employment; (4) Expand opportunities for Iowa enterpriseship in the area.

f. More funds for community modernization and to meet expanded housing needs.
Objectives: Identification of sources of funding for improvements to the housing sectors and preparation of a regional housing improvement plan.

In general, these goals and objectives, if achieved, will affect future land use in the area by providing an environment conducive to growth and by establishing facilities which will help control the pattern of growth.

3.0251 The fact that the member counties of Area XV supply financial support to XVRPC is an indication of their support for the documents which the Commission produces, including the OEDP.

3.03 In order to determine the impact of OGS on land use in the area, it is necessary to examine its relationship to the known local planning attitudes as reflected in the plans previously described in this section. The construction of OGS will have a different effect on area land use than the operation of OGS, and the two phases are discussed separately.

3.031 The short-term effects of OGS on land use plans in the area are primarily construction related and consist mostly of changes necessary to accomodate construction crews and their families. Such changes might include temporary trailer parks, commercial establishments and other facilities. It should be emphasized that any impacts of this type are temporary in nature and will not permanently disrupt plans for the area (see Section 4.0120).

3.032 The long-term effects of OGS on land use in the area are related to the existence of the physical facilities of OGS and of the energy it is designed to generate.

3.033 The Station Site consists of approximately 795 acres and is located in an area previously zoned for agriculture uses according to the Wapello County zoning ordinance. This acreage has since been rezoned for heavy industrial uses.

3.034 The fact that the plant exists might lead one to expect that additional industrial growth would occur in the vicinity of the plant due to the possibility of purchasing steam from the plant or of sharing it's coal handling and storage facilities. Although it is possible that plant facilities could be modified to allow the sale of steam to a buyer, it is considered highly unlikely. Unless excess capacity is designed into the plant's boiler, steam could only be provided during off-peak hours and even then it would be an unreliable source because OGS may be called on at any moment to provide its capacity to replace that of another plant in the system which may be having problems. The coal handling and storage facilities for the plant were designed to meet the needs of OGS and as such do not allow for the possibility of sharing the facilities with outside interests.

3.035 The goals outlined in all of the previously discussed plans are strongly related to the objective of long-term, self-sustaining economic growth in the area. Many factors will influence the attainment of this objective, one of which is the availability of sufficient amounts of energy to support the hoped for increase in economic activity. The addition of OGS to the Iowa Southern Utilities system will help to meet future energy needs of the area and thus facilitate the implementation of any proposed land use plans.

IV ENVIRONMENTAL IMPACTS OF THE PROPOSED PROJECT

4.01 Environmental Impacts of Plant Construction

4.011 Terrestrial Environment

4.0111 General. The impact of the construction and operation of the Ottumwa Generating Station can be generally stated as: loss of vegetation; loss of agricultural productivity; reduction and (mostly) displacement of breeding and feeding mammals, birds and herptiles; loss of insects and invertebrates; permanent disruption of normal succession and permanent changes in ecological recycling and productivity; and changes in the aesthetic quality of the area. Were this a natural, or near-natural area, these impacts would be severe indeed, and difficult to justify. However, the impact of the plant, relative to the degree of environmental disruption already present on the site, reduces the severity of the impact of the facility. Site clearing activities have been completed and construction of the facility is scheduled to be initiated in Spring 1977.

4.0112 Impact on vegetation. There will be a loss of about 3 acres of forest and 2 acres of grassland. The loss of this vegetation will contribute little to the potential for erosion, since the acreage represents only about 0.6 per cent of the total area of the site. The best pieces of forest are the small oak woods in the southwest portion of the area, and the gallery forest. The gallery forest probably acts, to some degree, as a filter of material running off the cultivated areas into the Des Moines River.

4.0113 Impact on terrestrial vertebrates. A number of species of mammals, birds and herptiles are resident on the site, either breeding, feeding and/or resting during migration. The construction of the plant will remove the habitat for these animals, resulting in displacement into other areas and local population depression for some species. Economic studies predict that the construction and operation of OGS will not induce growth adjacent to the study area. Refer to Chapter 3 for a discussion of future growth patterns near the OGS site.

4.0114 Impact on terrestrial succession and ecosystem function. It is expected that the Ottumwa facility will permanently prevent ecological succession from occurring, and will reduce ecological productivity and affect the efficiency of nutrient recycling and conservation. Construction activities will cause minimal erosion and consequent nutrient loss. Permanent effects will depend upon what kind of vegetation cover, if any, is returned to the area. Attractive, functional vegetative cover will serve to reduce the functional impacts of the facility.

4.0115 Aesthetic impact. The most difficult of the impacts to assess is the aesthetic impact, since the severity of this depends upon subjective judgment. However, it is certain that the visual aspect of the area will be changed, and that the view of the Des Moines River valley will be degraded to some extent.

4.0116 Water quality and biological elements. There will be some runoff from the plant site during the construction which will contribute to the turbidity of the Des Moines River and Avery Creek. Construction area runoff is subject to and will comply with NPDES regulations. These effects will be temporary (during construction period), and will be similar to those resulting from runoff from plowed fields. Sloped areas on the site will be seeded where practical and vegetation established as soon as possible.

4.01161 The construction of the water intake structure will result in unavoidable contributions to the turbidity of the Des Moines River. Increased turbidity will be temporary, and the effects will be minimized by sound construction practices.

4.0117 Air quality. During the construction period, there will be some combustion gas discharges to the atmosphere as the result of operating vehicles and carrying out various activities. These discharges will not significantly affect air quality since their concentrations will not exceed ambient air quality standards. The Iowa Department of Environmental Quality has regulations limiting the amount of visible emissions from gasoline and diesel-powered vehicles (Chapter 4.4.3 (2) (d) (2) and (3).

4.01171 There will be dust associated with some construction activities. No quantitative estimates have been attempted. Dust impacts from site preparation will not be substantially different from those resulting from recurring agricultural cultivation on the site.

4.01172 Iowa regulations require that reasonable precautions be taken to prevent particulate in sufficient quantities to create a nuisance (1973 I.D.R. p. 274). To meet those requirements, sprayed water will be employed to control dust during clearing of land, grading of roads, and construction operations.

4.01173 Concerning the OGS project, there will be no open burning. All construction waste materials, rubbish, and landscape waste will be either hauled away and disposed of by a commercial contractor or buried on the site.

4.0118 Noise effects. Construction activities at the Ottumwa Station will involve a fluctuating number of men and machines over an extended period of time. Construction noise, when considered in relation to any specific off-site listener, will vary on a daily, weekly, or longer basis. As the peak of construction activity approaches, the average noise levels will increase and noise quality will change as more and different types of machinery become involved. All of these factors constitute a changing noise environment that is complex to evaluate. For simplicity, estimates of noise emission given here are instantaneous values rather than 24-hour averages.

4.01181 The Noise Control Act of 1972 (86 stat. 1234) provides for the protection of the environment and local inhabitants from certain noise emissions. The Occupational Safety and Health Administration (OSHA) has jurisdiction over the construction worker's exposure and the Environmental Protection Agency (EPA) has issued guidelines for state and local governments to use in setting standards for ambient community noise[1].

4.01182 EPA guidelines which are presently non-regulatory suggest a 24-hour exposure level of 70 dBA as the maximum level of environmental noise which will prevent any measurable hearing loss over a lifetime; a level of 55 L_{dn} as the maximum level to prevent activity interference and annoyance for certain outdoor areas where human activity takes place; and a maximum level of 45 L_{dn} as the level which will permit spoken conversation, sleeping, working, recreation, and other activities which are part of the daily human condition in indoor residential areas, hospitals, and schools. "L_{dn}" represents the "L_{eg}" with a 10 dB nighttime weighting. "L_{eg} (24)" represents the sound energy averaged over a 24-hour period. The specified levels are not event or "peak" levels for sound, but rather an average of acoustic energy over 24 hours. Occasional higher sound levels are permissible as long as a sufficient amount of relative quiet is experienced for the remaining period of time. For example, the energy contained in an 8-hour average exposure to 75 dBA is equivalent to a 24-hour average 70 dBA exposure. For practical purposes, the former exposure is equivalent to the latter only when the average level for the remaining 16 hours of the day is less than about 50 dBA.

4.01183 At a typical construction site of this size, many types and sizes of equipment will be operating and producing noise. A composite noise level of 90 dBA can be considered a conservatively reasonable noise value, produced by many varieties of diesel powered construction equipment[2]. Higher than expected estimates were used to obtain worst-case situations. No parameters other than the maximum, instantaneous sound level and the distance from the source to the receiver were considered.

4.01184 The nearest off-site house to general site construction is approximately 650 feet away. At this distance, the machinery sound attenuates to about 68 dBA outside the house. Generally, the walls of most houses will further attenuate another 20 dBA or more, so the resulting interior sound level should be less than 48 dBA with the windows closed[3]. The sound level (about 68 dBA) will be noticeable, to a person working outside, but should be acceptable as a temporary nuisance; the inside level will be somewhat louder than the existing background noise level of the average house. These are maximum expected values and should occur only when the construction machinery is operating at its closest approach to the house. No construction activities are planned to be carried out at night.

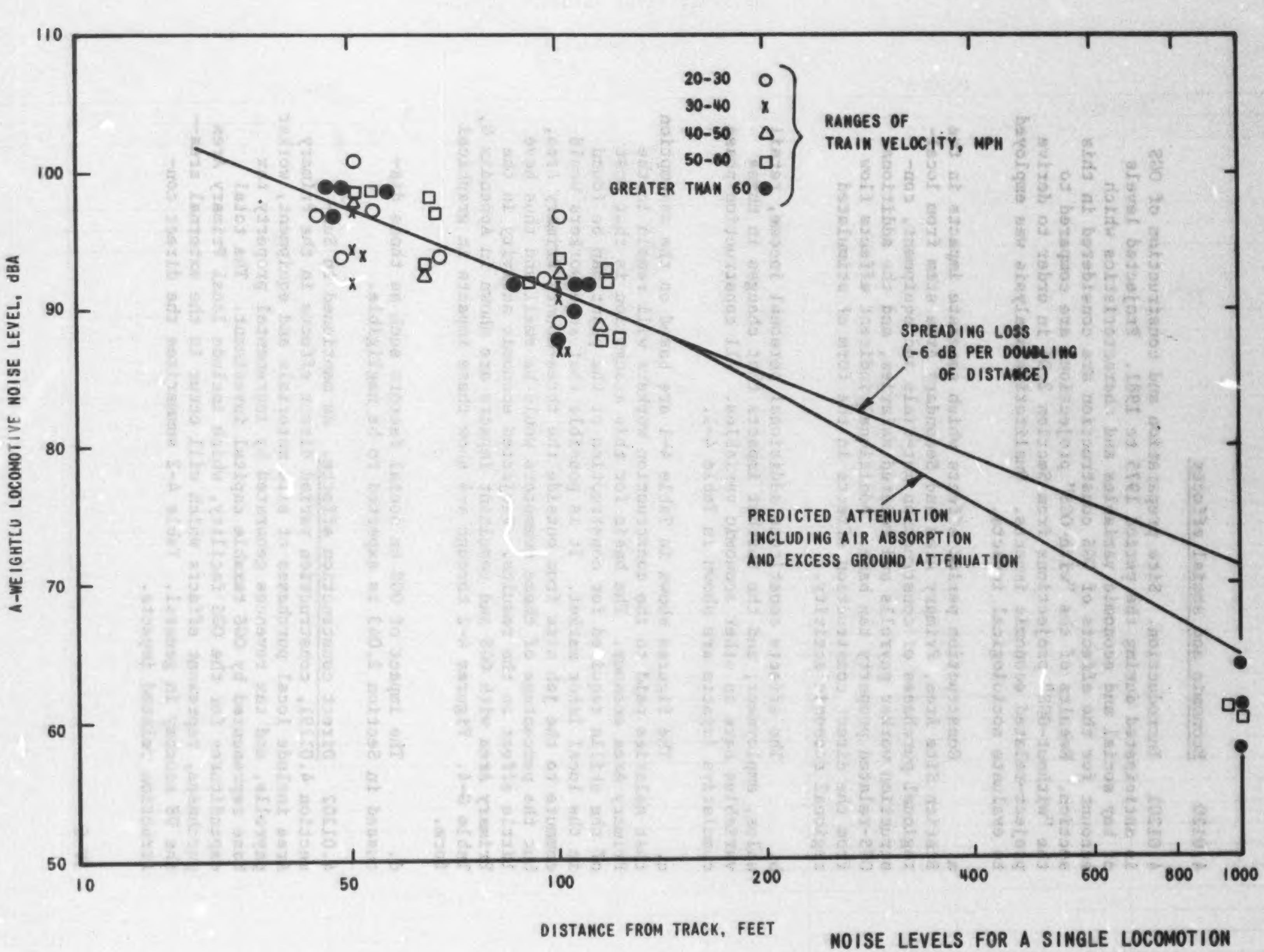
4.01185 The city of Chillicothe is adjacent to the site and the city residence nearest to one of the construction zones is approximately 1100 feet away. At this distance the construction noise level of 90 dBA will attenuate to about 63 dBA outside the residence. The walls of the house, with the windows closed, should lower this level to 43 dBA or less. Once again, these levels should be considered as maximums, occurring when construction machinery is closest to the residence.

4.01186 The existing train operation on Burlington Northern tracks located next to the OGS Site include one passenger train in both directions daily, 7 day a week, accounts for two movements per day. Freight trains number 14 per day in both directions accounts for 28 movements per day. The average train contains between 75 to 100 cars. All coal trains are 100 car lengths and move at a speed of 50 mph, all other trains travel at 60 mph.

4.01187 Once the construction of the railroad spur is complete, certain construction materials will be delivered to the site by rail. One engine and no more than about 25 cars are expected at any one time. Noise levels for a single locomotive have been measured and plotted as shown on Figure 4-1.

4.01188 The houses that would be affected most by the noise of operation of trains on the proposed rail spur presently lie closer to existing main line Burlington Northern railroad tracks than they will to the finished rail spur tracks. The noise from operation of a train on the proposed rail spur should be one-half the magnitude of the noise from the operation of the same train of the main line tracks.

4.01189 All other houses are at greater distances than the ones discussed here. Extreme cases have been chosen to reference the expected sound levels at other houses. It is anticipated that sould levels in the surrounding community will be quite tolerable in lieu of the estimated noise levels.



NOISE LEVELS FOR A SINGLE LOCOMOTION
WITH RESPECT TO DISTANCE

FIGURE 4-1

4.0120 Economic and social effects

4.01201 Introduction. Site preparation and construction of OGS is anticipated during the period 1975 to 1981. Projected levels of key social and economic variables and characteristics which account for the effects of OGS construction are considered in this section. Results of the "with-OGS" projections are compared to the "without-OGS" projections from Section 2.04 in order to derive project-related economic impacts. Qualitative analysis was employed to evaluate sociological impacts.

a. Construction period effects which generate impacts in the Station Site Area, Primary Area and Secondary Area stem from local-regional purchases of construction materials and equipment, construction worker payrolls and related salaries, and the additional OGS-related property tax base. Additional indirect effects flow from the direct construction effects in the form of stimulated regional economic activity.

b. The effects constitute additional personal income, retail sales, employment, and the further impacts that changes in these variables have on other economic variables. All construction phase cumulative impacts are shown in Table 4-1.

c. The figures shown in Table 4-1 are based on the assumption that salaries paid to the construction workers will remain in the Primary Area economy. The basis for this assumption is that most of the skills required for construction of the plant can be found in the local labor market. It is possible that some workers would commute to the job site from outside the three-county Primary Area, but the percentage of these commuters would be small and thus have little effect on the results. Projected economic activity in the Primary Area with OGS and resultant impacts are shown in Appendix G, Table G-4. Figures 4-2 through 4-4 show these impacts in graphical form.

d. The impact of OGS on social factors such as those discussed in Section 2.043 is expected to be negligible.

4.01202 Direct construction effects. As mentioned in Subsection 4.01191, construction period direct effects in the Primary Area include local purchases of site materials and equipment, worker payrolls, and tax revenues generated by incremental property tax base represented by OGS taxable capital investment. The total expenditures for the OGS facility, which include local Primary Area purchases, represent effects which will occur in the external area--the US economy in general. Table 4-2 summarizes the direct construction related impacts.

Table 4-1

PRIMARY AREA
CUMULATIVE DIRECT AND INDIRECT
ECONOMIC IMPACTS
DURING OGS CONSTRUCTION (1976-1981)
1981 DOLLARS

	Impact	Percentage Increase Due to OGS Impact
Employment, Man-Years	5,144	2.69
Personal Income	$120,339,000	4.12
Wages and Salaries	103,371,000	5.84
Profit and Proprietor Income	16,967,000	1.55
Disposal Income	112,946,000	4.22
Federal Income Tax Revenues	4,771,000	2.40
State Income Tax Revenues	2,620,000	6.66
Retail Sales	23,629,000	1.63
Retail Sales Tax Revenues	861,000	2.10
Bank Deposits, $-Years	10,428,000	0.53
Farm Income	-750,000	<0.31>
Real Estate Sector (APV, REV, PSV, VRLB)	Positive Impact	*
Property Tax Revenues (Current $)		
Direct, 1976-1982	19,532,000	*
Indirect	Positive Impact	*

*Not available.

TABLE 4-2

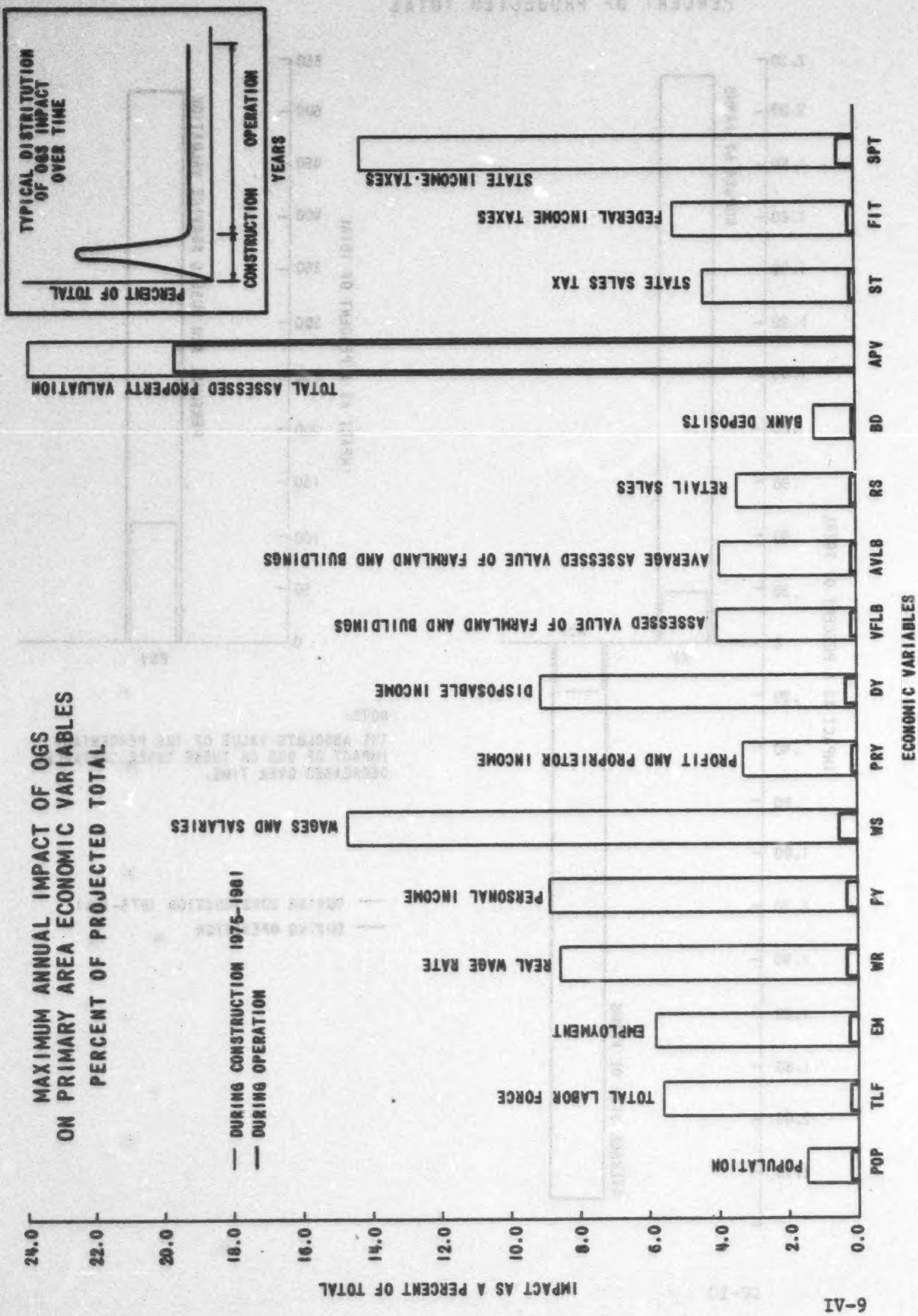
ECONOMIC IMPACTS - CONSTRUCTION PERIOD

	Direct Construction Effects							
	1976	1977	1978	1979	1980	1981	1982	Total
Estimated Total Direct Plant & Equipment Cost, 1981 dollars	10,160,000	51,525,000	64,104,000	62,894,000	44,751,000	8,466,000	-	247,900,000
Estimated Property Taxes** current $								
Site	-	76,000	545,000	1,069,000	1,206,000	1,218,000	1,230,000	5,344,000
ISU	-	-	-	365,000	1,305,000	2,252,000	2,090,000	6,812,000
IPS	-	-	-	140,000	503,000	868,000	1,114,000	2,625,000
IA.-Ill.	-	-	-	140,000	502,000	868,000	1,113,000	2,623,000
IPALCO	-	-	-	114,000	408,000	703,000	903,000	2,128,000
Total	-	76,000	545,000	1,828,000	3,934,000	5,909,000	7,250,000	19,532,000
Estimated Employment								
Estimated new resident work force	33	80	347	457	140	*		
Average annual work force	90	241	589	921	420	*		
Estimated employment man-hours	180,000	482,000	1,178,000	1,842,000	840,000	56,000		4,578,000
Construction Payroll								
Estimates annual - $	2,539,200	6,727,500	16,442,700	25,702,500	17,588,100	*		69,000,000
Deflated annual 1981 $	3,077,300	7,844,900	18,448,700	27,748,400	18,274,000	*		78,393,300
Primary Area Expenditures								
Material & equipment - $	110,700	561,400	698,500	685,300	487,600	92,200		2,635,700
Deflated material & equipment - 1981 $	134,200	654,700	783,700	739,800	506,600	92,200		2,911,200

*Negligible.

**Five year construction budget was used to determine additions to be used for property taxes (State of Iowa formula also used; property taxes lag construction period by one year.)

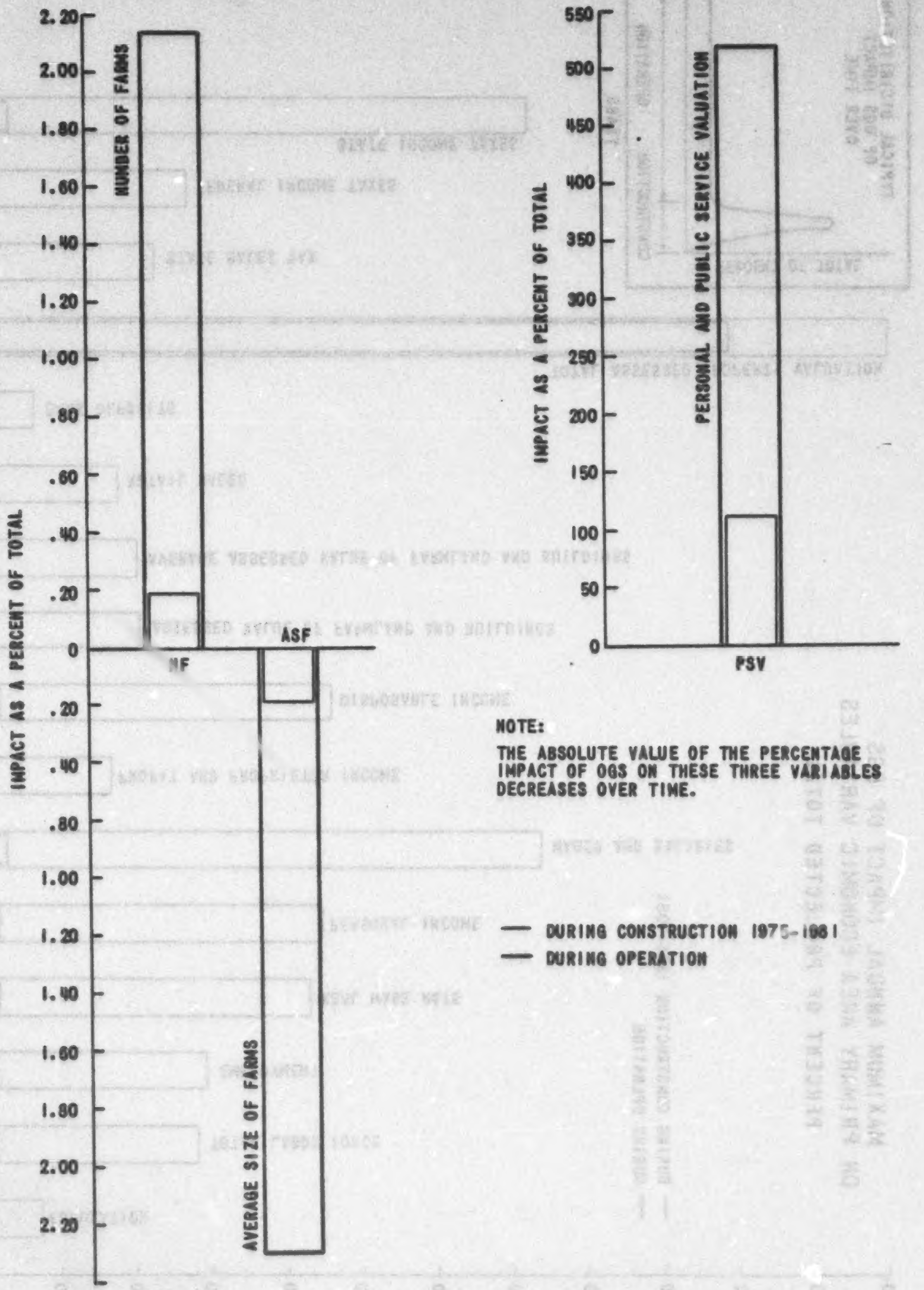
FIGURE 4-2



MAXIMUM ANNUAL IMPACT OF OGS ON PRIMARY AREA ECONOMIC VARIABLES PERCENT OF PROJECTED TOTAL

ON PRIMARY AREA ECONOMIC VARIABLES
PERCENT OF PROJECTED TOTAL

FIGURE 4-3

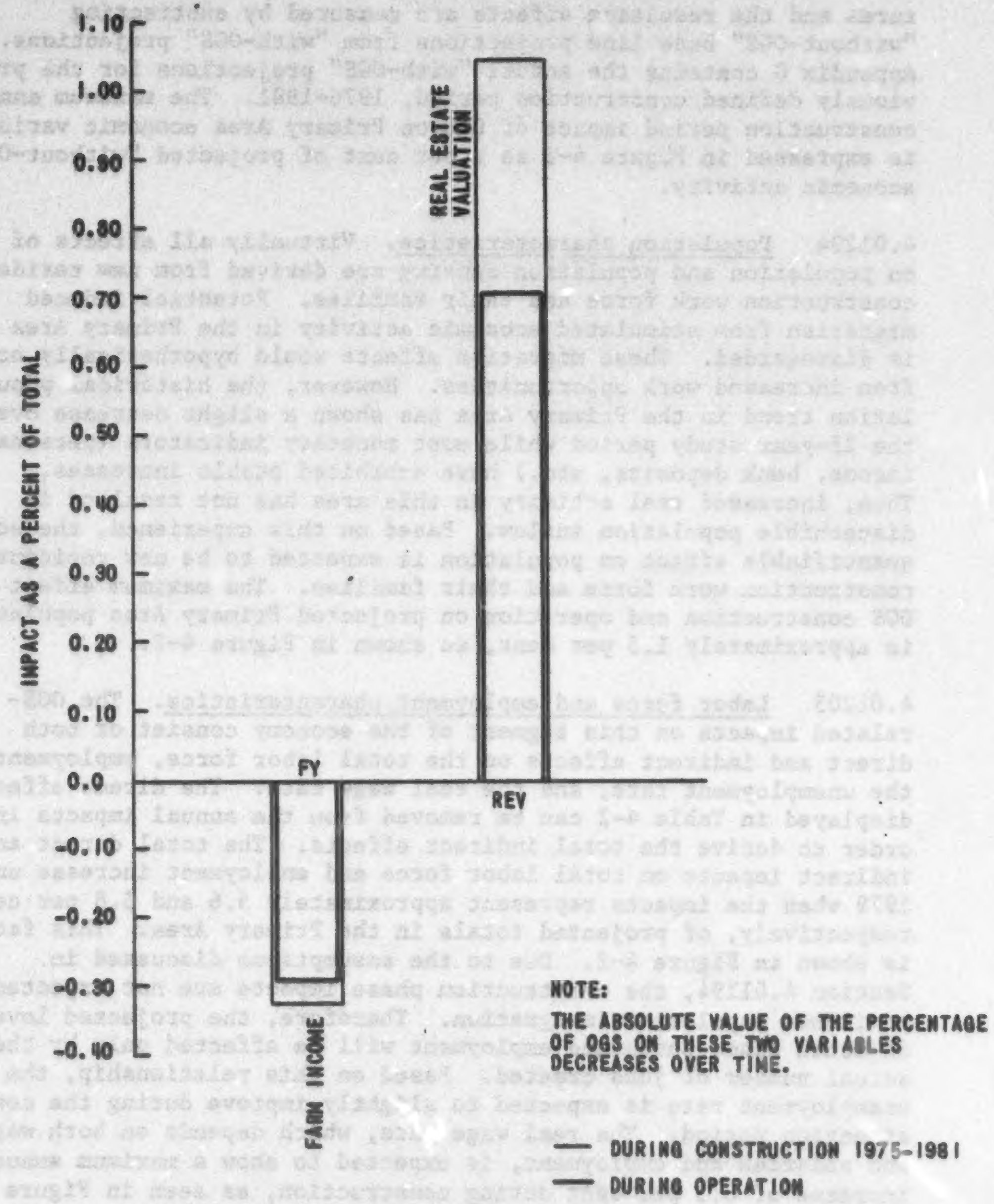


NOTE:

THE ABSOLUTE VALUE OF THE PERCENTAGE IMPACT OF OGS ON THESE THREE VARIABLES DECREASES OVER TIME.

MAXIMUM ANNUAL IMPACT OF OGS ON PRIMARY AREA ECONOMIC VARIABLES PERCENT OF PROJECTED TOTAL

FIGURE 4-4



4.01203 Indirect construction effects. Direct project expenditures and effects discussed in Section 4.01192 will produce further changes in the Primary Area and other areas by stimulating economic activity. "With-OGS" projections of Primary Area economic activity are derived from the econometric model. The exogenous and other key economic variables are stimulated by direct construction expenditures and the resulting effects are measured by subtracting "without-OGS" base line projections from "with-OGS" projections. Appendix G contains the actual "with-OGS" projections for the previously defined construction period, 1976-1981. The maximum annual construction period impact of OGS on Primary Area economic variables is expressed in Figure 4-2 as a per cent of projected "without-OGS" economic activity.

4.01204 Population characteristics. Virtually all effects of OGS on population and population density are derived from new resident construction work force and their families. Potential induced migration from stimulated economic activity in the Primary Area is disregarded. These migration effects would hypothetically occur from increased work opportunities. However, the historical population trend in the Primary Area has shown a slight decrease over the 25-year study period while most monetary indicators (personal income, bank deposits, etc.) have exhibited stable increases. Thus, increased real activity in this area has not resulted in discernible population inflow. Based on this experience, the sole quantifiable effect on population is expected to be new resident construction work force and their families. The maximum effect of OGS construction and operation on projected Primary Area population is approximately 1.5 per cent, as shown in Figure 4-2.

4.01205 Labor force and employment characteristics. The OGS-related impacts on this segment of the economy consist of both direct and indirect effects on the total labor force, employment, the unemployment rate, and the real wage rate. The direct effects displayed in Table 4-2 can be removed from the annual impacts in order to derive the total indirect effects. The total direct and indirect impacts on total labor force and employment increase until 1979 when the impacts represent approximately 5.6 and 5.8 per cent, respectively, of projected totals in the Primary Area. This fact is shown in Figure 4-2. Due to the assumptions discussed in Section 4.01194, the construction phase impacts are not expected to induce population immigration. Therefore, the projected levels of total labor force and employment will be affected only by the actual number of jobs created. Based on this relationship, the unemployment rate is expected to slightly improve during the construction period. The real wage rate, which depends on both wages and salaries and employment, is expected to show a maximum annual increase of 8.5 per cent during construction, as seen in Figure 4-2.

4.01206 Income levels. The effects discussed in this section concern personal income and its components; wages and salaries, profit and proprietor income, and farm income. Each year's "with-OGS" projections take into account the multiplier effects resulting from OGS worker payrolls and purchases of construction materials and equipment in the Primary Area. As workers spend their incomes on goods and services they indirectly generate further income for employees and owners of local business. Local purchases of construction materials and equipment produce similar effects by stimulating retail sales, profit and proprietor income, wages and salaries, personal income and disposal income.

a. Construction phase impacts on personal income, wages and salaries, profit and proprietor income, and disposable income increase until they attain their expected maximum effect in 1979. Additional personal income in the Primary Area is expected to amount to almost 9 per cent of the base line level, as shown in Figure 4-2. Wages and salaries and profit and proprietor income reach respective levels of 14.6 per cent and 3.2 per cent above the base line in 1979, the peak construction phase impact year. Disposable income is projected to increase in approximately the same proportion as personal income. The indirect effects on wages and salaries are expected to amount to about 25 per cent of the total impact over the construction period.

b. The effect of OGS construction on farm income in the area is expected to be less than 0.4 per cent of total projected farm income. Projected maximum annual impact of OGS on farm income is shown in Figure 4-2.

4.01207 Agricultural land use. Projected OGS impacts on number of farms, average size of farms, and value and average value of farmland and buildings are shown in Figure 4-3. Land in farms is not charted because the impact is less than 0.1 per cent. Although all other agricultural indicators are charted, the only substantial effect on this sector is the expected temporary effect on assessed value of farmland and buildings. The projected impacts shown in Figure 4-3 are better interpreted as the probable positive direction of change, rather than the actual magnitude of effects upon assessed valuation of real and personal property.

4.01208 Industrial and business activity. By 1979, OGS-related expenditures are expected to stimulate retail sales by 3.4 per cent. This is the year of maximum projected impact on retail sales. Bank deposits are stimulated by OGS-related economic activity as shown in Figure 4-2. Bank deposits are projected to increase by a maximum of 1.1 per cent in 1979.

4.01209 Real estate sector. Virtually no indirect effects due to OGS are expected to occur in this sector. There are no projected indirect impacts on total assessed property valuation, real estate valuation, and real estate valuation per square mile and only an insignificant impact on personal and public service valuation.

4.01210 Government revenues. Retail sales taxes and federal and state income tax revenues in the Primary Area are all expected to increase during construction. Again, 1979 is the year of maximum expected impact when additional retail sales tax will constitute approximately 4.3 per cent of "without-OGS" levels. Federal and state income tax revenues are expected to increase to a maximum in 1979 of 5.2 and 14.3 per cent, respectively. These annual effects quickly return to near preconstruction levels as do most other impacts measured by the Primary Area model.

4.01211 Community profile/public facilities and services. The community profile, as portrayed in Section 2.043 is not expected to vary significantly due to the construction or operation of OGS. Population age, migration and education will remain virtually unchanged due to the small number of OGS workers relative to the population already in the area. Other demographic factors discussed in Section 2.043 are also not expected to exhibit significant variation.

a. As previously discussed, some of the facilities and services in the areas surrounding the proposed Station Site are presently inadequate while others enjoy excess capacity. For those facilities which are already lacking, the impact of OGS will be negligible because the addition of a relatively few people will not significantly affect the quality of service in the area. Those facilities which have excess capacity also will not be appreciably affected by the presence of OGS in the area. Construction period impacts will take the form of temporary requirements for housing, school facilities, and community services such as churches and recreational facilities. Operation period impacts will be permanent in nature but of a smaller magnitude than those experienced during the construction period.

4.02 Environmental Impacts of Generating Station Operation

4.021 Air Quality Control Standards. To describe the effects of combustion emissions, it is important to describe the applicable air quality standards for the project site.

4.0211 There are two general types of regulations applicable to the discharge of air pollutants. *Emission standards* limit the rate of air pollutant discharge from the plant. *Ambient air quality standards* limit the resulting air pollutant concentration that may occur at ground level. Federal and Iowa emission standards and ambient air quality standards are discussed for particulate matter and oxides of both sulfur and nitrogen.

4.0212 Federal standards applicable to the plant are promulgated by the U.S. Environmental Protection Agency (EPA): Iowa standards, by the Iowa Department of Environmental Quality.

4.0213 Emission standards are expressed as limits on the number of pounds per unit of heat input, generally as pounds per million Btu of heat input (lb/MBtu). Emission standards are also established as limitations on the visibility of emissions. Visibility limits are expressed as the permissible per cent opacity of a discharge or sometimes as Ringelmann numbers which correspond approximately to 20 per cent increments in opacity.

4.0214 Ambient air quality standards are generally expressed as pollutant concentrations; i.e. an amount per unit of volume. Micrograms per cubic meter ($\mu g/m^3$) or parts per million (ppm) are used to express pollutant concentrations in air.

4.0215 Federal emission standards are applicable to particulate matter, sulfur dioxide, and nitrogen dioxide. The federal standards are summarized in Table 4-3.

TABLE 4-3

FEDERAL EMISSION STANDARDS

Air Pollutant	Maximum Emission Rate lb/MBtu	Estimated Maximum Ottumwa Generating Station Emission Rate lb/MBtu
Sulfur Dioxide	1.2	1.2
Particulate Matter[a]	0.10	0.10
Nitrogen Dioxide	0.70	0.70

[a] The opacity of emissions shall not exceed 20 per cent.

4.0216 Iowa emission standards applicable to particulate matter, sulfur dioxide, and nitrogen dioxide are the same as the federal standards.

4.0217 The Ottumwa Plant is situated within the Southeast Iowa Intrastate Air Quality Control Region (AQCR) established by the EPA.

4.0218 The federal ambient air quality standards are summarized in Table 4-4. Iowa has adopted the federal ambient air quality standards.

TABLE 4-4

FEDERAL AMBIENT AIR QUALITY STANDARDS AND ESTIMATED CONCENTRATION OF POLLUTANTS FROM OPERATION OF OTTUMWA STATION

Air Pollutant	3-Hour Average[a] µg/m^3(ppm)	24-Hour Average[a] µg/m^3(ppm)	Annual Average[b] µg/m^3(ppm)
Sulfur Dioxide			
Primary Standard	—	365(0.14)	80(0.03)
Secondary Standard	1300(0.50)	—	—
Estimated Ottumwa Generating Station	105(0.04)	26(0.01)	1.3(0.0005)
Suspended Particulates		µg/m^3	µg/m^3
Primary Standard	—	260	75
Secondary Standard	—	150	60
Estimated Ottumwa Generating Station	—	0.7	0.03
Nitrogen Dioxide			
Primary Standard	—	—	100(0.05)
Secondary Standard	—	—	100(0.05)
Estimated Ottumwa Generating Station	—	—	0.8(0.0004)

[a] The maximum 3-hour and 24-hour average concentrations are not to be exceeded more than once during a year.

[b] The annual average for particulate matter is computed as a geometric mean, whereas the annual average for sulfur and nitrogen dioxide is an arithmetic mean.

4.0219 The results of the ambient air quality monitoring program conducted at the Ottumwa Generating Station site showed that the annual average background concentration of sulfur dioxide, suspended particulates, and nitrogen dioxide were 5.1 μg/m^3, 65.4 μg/m^3 and and 10.5 μg/m^3 respectively (see APPENDIX D). The predicted increase in the annual average pollutant levels due to the operation of the Ottumwa Generating Station are expected to be of a small magnitude as shown in Table 4-4.

4.022 Emissions dispersion analysis. In preceding subsections applicable federal and Iowa emission standards and ambient air quality standards were explained and the Ottumwa Plant air pollution control system was described. Fuel selection, equipment design, and the use of combustion gas cleaning equipment are required to comply with the most stringent of emission standards.

4.0221 Plant stack design is based upon ambient air quality standards. Ground level air pollutant concentrations resulting from atmospheric discharges of cleaned combustion gases must comply with the most stringent applicable ambient air quality standards. Stack design is accomplished by use of a computational model that estimates gaseous dispersion and resulting ground level concentrations of air pollutants discharged from alternative stack configurations. The computational model and data to which the model was applied are described in APPENDIX E. The dispersion analysis is summarized and discussed in the following paragraphs.

4.022 Ground level air pollutant concentrations resulting from plant discharges have been analyzed on the basis of the maximum legal air pollutant emission rates. It is expected that actual emission rates will be below these legal limits; however, this analysis provides the worst case evaluation of plant operation.

4.0223 The ambient air quality standards described above utilize 3-hour, 24-hour, and annual average periods. The analysis of the Ottumwa Generating Station air pollutant discharges utilize these averaging times and maximum ground level concentrations have been estimated for each of these time periods as shown in Table 4-5.

TABLE 4-5

ESTIMATED MAXIMUM GROUND LEVEL AIR POLLUTANT CONCENTRATIONS RESULTING FROM OPERATION OF THE 727 MW (GROSS) UNIT AT MAXIMUM CAPABILITY WITH MAXIMUM LEGAL AIR POLLUTANT EMISSIONS DISCHARGED FROM A 600-FOOT STACK

Air Pollutant	Estimated Maximum Average Ground Level Concentration 3-Hour Average $\mu g/m^3$(ppm)	 24-Hour Average $\mu g/m^3$(ppm)	 Annual Average $\mu g/m^3$(ppm)
Sulfur Dioxide	105(0.04)	26(0.01)	1.3 (0.0005)
Particulate Matter	—	0.7	0.03
Nitrogen Dioxide	—	—	0.8 (0.0004)

4.0224 In Table 4-6, the estimated ambient air concentrations of SO_2 and TSP due to emissions from OGS are compared to the prevention of significant deterioration increments for these pollutants. The diversion modeling indicates that emissions from OGS will not cause a violation of TSP or SO_2 deterioration increment.

4.0225 The maximum expected ground level concentrations of trace elements and the minimum concentration detectable by emission spectroscopy, are shown in Table 4-7. The trace elements are dispersed in two forms, as gaseous compounds of the element itself, and as a component of the fly ash.

4.02251 The first part of Table 4-7 shows the elements which would be oxidized at the temperatures within the boiler, and would form gases, i.e. arsenic; mercury, and selenium. Once these gases were emitted from the chimney, they would be dispersed in the same pattern as sulfur dioxide. The ground level concentrations shown were calculated on this basis. The table also shows that the ground level concentrations are far below the minimum detectable levels and the limits for human exposure.

4.02252 The second part of Table 4-7 shows the maximum expected ground level concentrations of fly ash. The concentrations of the trace elements in the fly ash is shown in Table 4-8. Because the fly ash is dispersed over a wide area and contains only minute

TABLE 4-6

COMPARISON OF SIGNIFICANT DETERIORATION AMBIENT AIR QUALITY INCREMENT WITH ESTIMATED MAXIMUM GROUND LEVEL AIR POLLUTANT CONCENTRATIONS RESULTING FROM OPERATION OF GENERATING UNIT AT MAXIMUM CAPABILITY WITH MAXIMUM LEGAL AIR POLLUTANT EMISSIONS DISCHARGED FROM A 600-FOOT STACK

MICROGRAMS PER CUBIC METER (PARTS PER MILLION)

Parameter	3-Hour		24-Hour		Annual	
	Increment	Plant	Increment	Plant	Increment	Plant
Sulfur Dioxide	700(0.27)	105(0.04)	100(0.09)	26(0.01)	15(0.006)	1.3(0.0005)
Particulate Matter	—	—	30	0.7	10	0.03

TABLE 4-7

TRACE ELEMENT EMISSIONS--OTTUMWA GENERATING STATION
MAXIMUM EXPECTED GROUND LEVEL CONCENTRATIONS

GASEOUS EMISSIONS

Component	Stable Form in Flue Gas	3-Hour Average ppb (mg/m³)	24-Hour Average ppb (mg/m³)	Annual Average ppb (mg/m³)	Minimum[a] Detectable Concentration ppb (mg/m³)	Limits For[b] Human Exposure mg/m³
Arsenic	As_2O_3	0.008 (0.066)	0.0003 (0.0025)	0.0002 (0.0016)	1,000 (8229.6)	0.5
Mercury	Hg_2O or Hg	0.0007 (0.012)	0.0003 (0.005)	0.0002 (0.003)	70 (1214.5)	0.1
Selenium	SeO_2	0.0003 (0.001)	0.00009 (0.0004)	0.0000006 (0.000003)	300,000 (1,380,000)	0.2

PARTICULATE EMISSIONS

Component	3-Hour Average μg/m³	24-Hour Average μg/m³	Annual Average μg/m³
Fly Ash	4.8	1.04	0.096

[a] Minimum concentration detectable by emission spectroscopy.

[b] US, Federal Registry, Vol. 36, No. 105.

TABLE 4-8

FLY ASH TRACE ELEMENT ANALYSIS
OTTUMWA GENERATING STATION

Element	Stable Form in Fly Ash	Concentration in Fly Ash ppm
Barium	BaO or $BaSO_4$	477-2,350
Beryllium	BeO	0.34-10.7
Boron	B_2O_3	139-848
Cadmium	CdO	1.86-21.3
Chromium	Cr_2O_3	9.3-164
Copper	CuO	44.2-214
Cyanide		1.16
Fluoride	CaF_2	930-4,070
Gallium	Ga_2O_3	0.35-10.7
Iron	Fe_2O_3	9,732-34,650
Lead	PbO	2.3-36
Nickel	NiO	2.3-70
Thorium	ThO_2	11.3-5,490
Uranium	UO_2	7.0-34.9
Vanadium	V_2O_3	116-826
Zinc	ZnO	51.2-365

quantities of trace elements, the trace elements should not present any threat to plant or animal life.

4.02253 The maximum emission concentrations of trace elements expected from the Ottumwa Generating Station together with the limits for human exposure are shown in Table 4-9. The trace elements listed will be contained in the fly ash that is emitted from the stack. The electrostatic precipitator will remove 99.4 per cent of the ash, and only 0.6 per cent will be emitted. The concentrations of trace elements given in Table 4-9 are well below the limits of human exposure. Generally, the quantities are so small that they cannot be detected by the analytical techniques presently available.

4.02254 The fly ash collected by the electrostatic precipitator system will be transported by water (sluiced) to the ash storage pond. Since the ash will be carried by water, there will be no release of ash particles to the atmosphere. The ash pond is lined with a natural layer of clay which will prevent leaching of heavy metals from the pond. (See Section 4.02413, page IV-29.)

4.02255 The estimated amounts of trace elements that will be disposed in the ash pond and emitted from the stack during the 30-year life of OGS are given in Table 4-10. It is evident that the majority of the materials will be confined to the ash storage pond. As shown in Table 4-9, the maximum expected concentrations of trace elements contained in the stack emissions will be far less than the limits for human exposure, and they also should have no adverse impacts on fauna and flora on or near the site area.

4.023 Noise effects. From a technical point of view, noise is discordant sound resulting from nonperiodic vibrations in air. Noise is more simply defined as unwanted sound and has sometimes been termed sound without value. Sound generally refers to any audible disturbance of the air, while noise refers to a particular type of sound, usually discordant. Sound generally is said to become noise when it becomes a nuisance, either because of the quality of the sound, the loudness, or both. A certain type of sound may be agreeable sound to one listener and an objectionable "noise" to another. A sound level that is pleasing to one listener could be too soft for another or too loud for a third. The disturbance characteristics of noise are subjective and not easily quantifiable.

4.0231 The Environmental Protection Agency (EPA) has established guidelines for state and local governments to use in setting noise standards[4]. The Ottumwa noise study will be compared to four of the more significant EPA noise level guidelines: $L_{eq(24)}$, L_{dn} Outdoors, L_{dn} Indoors, and L_n Sleep. $L_{eq(24)}$ is set at 70 dBA and represents

TABLE 4-9

MAXIMUM EMISSION CONCENTRATIONS OF TRACE ELEMENTS IN FLY ASH EXPECTED FROM OTTUMWA GENERATING STATION COMPARED TO LIMITS FOR HUMAN EXPOSURE, MICROGRAMS PER CUBIC METER

Element	3-Hour Average	24-Hour Average	Annual Average	Limits of[a] Human Exposure
Barium	0.0113	0.0024	0.000230	0.5
Beryllium	0.00005	0.00001	0.000001	0.002[b]
Boron	0.0040	0.00090	0.000081	15.0
Cadmium	0.0001	0.00002	0.000002	0.2[b]
Chromium	0.0007	0.0002	0.000016	0.5
Copper	0.00103	0.0002	0.000020	1.0
Cyanide	0.000006	0.000001	0.0000001	5.0
Fluoride	0.0200	0.00423	0.000390	2.5
Gallium	0.00005	0.00001	0.000001	—
Iron	0.1663	0.0360	0.003326	10.0
Lead	0.0001	0.00004	0.000003	0.2[b]
Nickel	0.0003	0.00007	0.000007	1.0
Thorium	0.0263	0.00570	0.000527	—
Uranium	0.0002	0.00004	0.000003	0.2
Vanadium	0.0040	0.00090	0.000080	0.5
Zinc	0.0018	0.00040	0.000035	5.0

[a] US Federal Registry, Vol. 36, No. 105.

[b] 8-hour time weighted average.

TABLE 4-10

ESTIMATED AMOUNTS OF TRACE ELEMENTS ASSOCIATED WITH THE OPERATION OF OGS FOR 30 YEARS

(55.8 Percent Average Load Factor)

Element	Total Amount Disposed in Ash Pond tons	Total Amount Emitted From Stack tons
Arsenic	0	26-147
Barium	2605-12,842	13-62
Beryllium	2.2-58	0.009-0.27
Boron	76-4633	4-23
Cadmium	10-117	0.05-0.55
Chromium	50-890	0.24-4.3
Copper	241-1196	1.2-5.7
Cyanide	6	0.03
Fluorine	5078-22,182	24-107
Gallium	2.2-58	0.009-0.027
Iron	53,121-189,000	255-912
Lead	13-197	0.06-0.15
Mercury	0.06-0.6	0.005-1.3
Nickel	13-379	0.06-1.83
Selenium	0	0.63-13.2
Thorium	61-29,900	0.29-144
Uranium	38-190	0.18-0.95
Vanadium	635-4509	3-21
Zinc	277-1992	1.3-9.5

the maximum allowable sound energy averaged over a 24-hour period which will prevent hearing loss (indoors and outdoors). The L_{dn} Outdoors is set at 55 dBA and represents the maximum allowable energy level over a 24-hour period to prevent conversation interference, outdoor activity interference and annoyance in residential areas and farms, other outdoor areas where people spend widely varying amounts of time, and other places in which relative quiet is a condition for use. The L_{dn} Indoors is set at 45 dBA and represents the maximum allowable energy level over a 24-hour period to prevent indoor activity interference and annoyance in indoor residential areas. Finally, the L_n Sleep is set at 32 dBA and represents the EPA recommendation of the maximum allowable energy level between the hours of 2200 and 0700 to prevent sleep disturbance. The EPA states that these levels are not to be construed as standards since they do not take into account cost or feasibility. Nor should they be thought of as discrete numbers, since they are defined in terms of energy equivalents[5].

4.0232 The predicted values of noise levels to be presented are considered high. The model used calculate attenuation considered only source strength, decay with distance, and molecular air absorption. No consideration was given to attenuation which might result from terrain irregularities, wind, vegetation, or other factors. The noise values at any point outside the station boundary are expected to be lower than the values predicted by the model.

4.0233 The first step in the study of noise from station operation was to determine the most likely sources for noise. In this particular case the sources determined were the river intake pumps, the main cooling tower fans, the bus tie transformer, the steam generator, the turbine, the scrubber/precipitator, the coal crusher, and the rotary car dumper.

4.0234 Values for the noise output of each source were determined, either through manufacturer's data or mathematical models. Geographic coordinates, including height above grade, were given to each source and to the boundaries of the area under consideration.

4.0235 A background noise level of 35 dBA was assumed for the Ottumwa Site area, as the setting is rural with no nearby interstate highways or large cities. There is noise from the traffic on the roads in the area and from agricultural operations. The background and all other noise levels considered in development of the contours were derived from worst possible conditions. Actual conditions, therefore, will not exceed predictions.

4.0236 The octave noise spectra for each source, source coordinates, source height, the area of ground to be considered, and the background noise level were all inputs to a model which yielded an isopleth of noise values as shown on Figure 4-5. This figure displays the sources of noise and the isolines of even numbered dBA.

4.0237 The Ottumwa Generating Station plant site is in rural Iowa, approximately 8 miles north of Ottumwa, Iowa. At this distance the operational noise from the facility will not be heard.

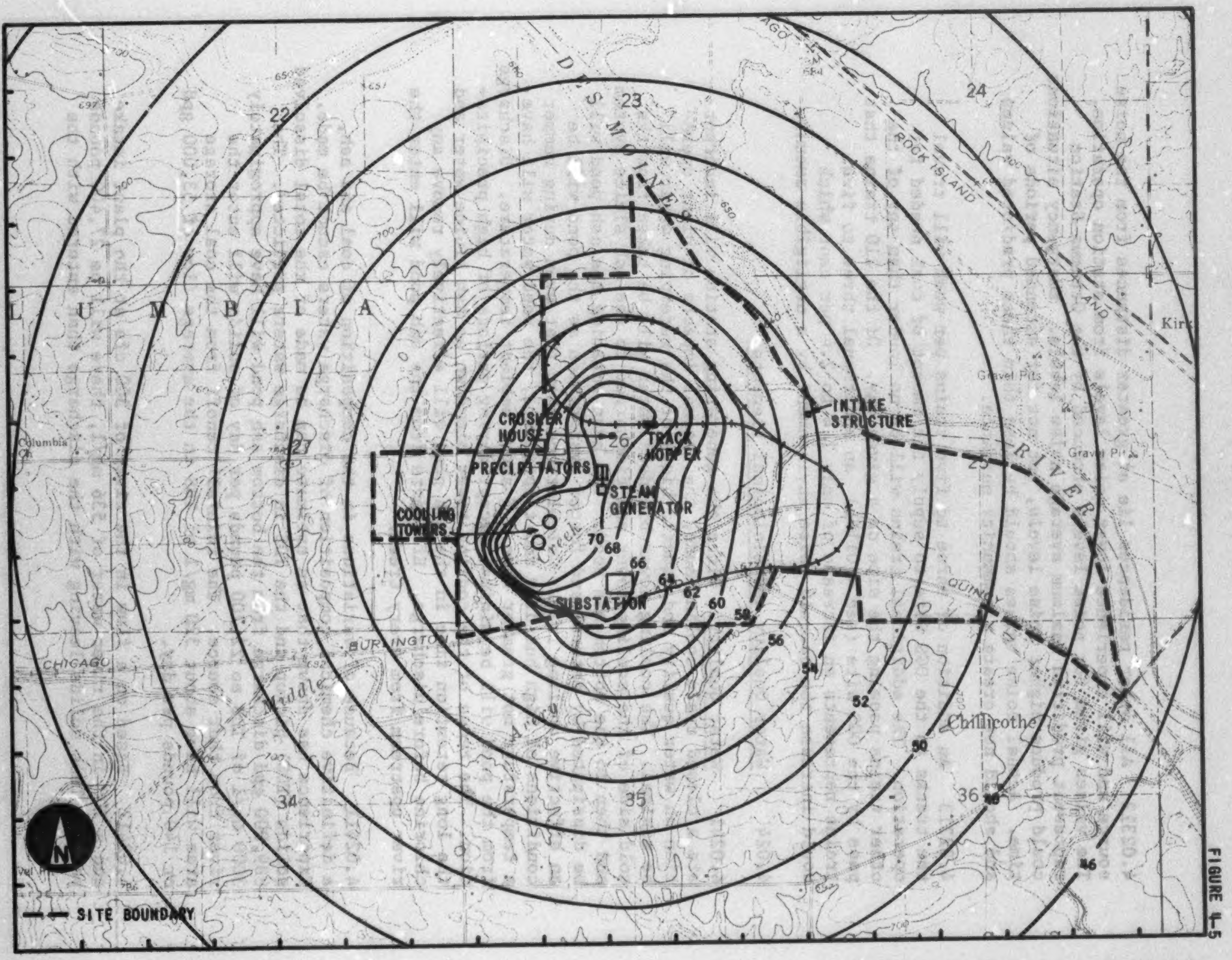
4.0238 The situation is different with respect to Chillicothe, Iowa, which shares common property boundaries with the site. Figure 4-5 shows the relationship between the site, the major noise producing equipment, Chillicothe, and the surrounding countryside with isopleths representing estimated maximum average noise values superimposed. As can be seen, the northwest fringe of Chillicothe will receive approximately 49 dBA and will therefore comply with all of the EPA's outdoor noise guidelines. A house of typical construction with partially open windows will attenuate approximately 15 dBA[6,7] so the resulting indoor noise level for this house would be about 34 dBA; this value complies with all but the L_n Sleep guideline. Closing the windows in this house will result in another 5 dBA reduction and should render the plant noise indistinguishable from the background noise of the house and the city.

4.0239 The nearest residence to the steam generator also receives the highest noise level. This residence is southeast of the central complex and is predicted to receive approximately 56 dBA outside the structure. This value is very slightly higher than the EPA L_{dn} Outdoor value of 55 dBA. Assuming typical construction, this residence should experience about 41 dBA indoors with the windows open and 36 dBA with them closed. The former value is within EPA guidelines, but the latter is 4 dBA higher than the L_n Sleep guideline.

4.02310 While it may appear, at first consideration, that this residence may be subject to excessive noise, it must be remembered that the model considered only source strength and decay with distance. Once such parameters as wind, terrain, and ground cover are introduced, the noise values at any point on Figure 4-5 should drop by several dBA or more.

4.02311 After station operation begins, most of the site will be covered by native grasses, shrubs, and trees. The sound attenuation over thick grass and through shrubbery is significant. For a 1000 hertz tone, and source and receiver heights of 2.5 meters (8 feet), the attenuation can be as high as 23 dBA per 100 m (326 feet)[8]. Source heights involved at the Ottumwa Station are greater, but source-receiver distances are much longer, so that such attenuation is nonetheless expected to be significant.

FIGURE 4-5



PREDICTED STATION OPERATION
NOISE LEVELS IN dBA

4.02312 All other residences lie at greater distances from the noise source and will experience lower noise levels from station operation. The values given for noise levels produced by the Ottumwa Station represent predicted maximum average noise levels. Emergency situations could produce higher noise levels, but not for extended periods of time. Actual noise values should be less than these predicted values and should not create a community nuisance.

4.02313 An addition of three to five trains per week will travel the tracks to the OGS Site to supply the amount of coal needed for operation. The additional trains will be no louder than any of the other trains passing the site on a given day. Of the 210 trains that pass by the OGS site (see 4.01196), an additional three to five trains represents an increase of only 1.4 to 2.4 per cent which would increase the overall noise environment by a negligible amount.

4.024 Water Quality and Biological Elements

4.0241 Water quality. Since the generating station will incorporate a closed cycle cooling mode, the thermal impacts of plant operation on water quality and aquatic biota of the receiving water will be minimal. The cooling tower blowdown water will be taken from the cold side of the cooling tower and discharged to the ash sluice system and then to the bottom ash pond. The heat entering the ash pond will be dissipated by natural and forced evaporation as the pond will be an effective cooling lake. Calculations show that even during summer conditions of high humidity and temperature, the pond water will have a temperature not greater than 5 F above ambient temperature. Discharge from the pond will be minimal except during periods of high precipitation. The reuse of the cooling tower blowdown as ash sluice water and the long retention time in the ash pond will effectively remove any chlorine before discharge. Effluents from the ash pond will enter the river upstream from Avery Creek.

4.02411 Because of variations in the composition of coal and ash, a definitive chemical composition of discharge waters cannot be made. Experience has shown that an estimate can be made of the total dissolved solids (TDS) pickup and the TDS in discharge waters predicted. The 889,000 gpd discharge from the bottom ash pond will have approximately 3000 mg/1 of TDS so 22,200 pounds per day of solids will enter the river from that source. The rainfall runoff from the coal storage area will have about 320 mg/1 of TDS in the average flow of 53,000 gpd or 140 pounds per day.

4.02412 Based on a flow in the river of 300 cfs at the plant intake and a TDS in the river water of 536 mg/1, there will be 27,400 pounds per day less solids leaving with the discharge than entered with the raw water.. Because of a consumptive use of water in the plant the concentration of TDS in the river downstream, after adequate mixing, will be about 548 mg/1.

4.02413 Very little historical data are available on the presence of toxic or hazardous materials in ash transport waters or coal pile runoff water. What little data are available indicate that materials which might be considered hazardous are present in such minute quantities that they are not readily detectable.

4.02414 The treated sewage effluent also will be discharged into the ash pond prior to entering the Des Moines River and will have no significant effect on the water quality of the river. Studies show that the ash pond will be essentially impervious and leachates are not expected to enter the Des Moines River or Avery Creek.

a. During December 1976, permeability tests were conducted by Patzig Testing Laboratories Co., Inc., Des Moines, Iowa on samples from nine borings. As shown on Figure 4-6 the borings were made within the ash storage areas and the coal storage area.

b. The permeability tests were conducted on 2 and 3 inch diameter, undisturbed, Shelby-tube samples taken at depths of from 1 to 6 feet. The falling-head tests of permeability were conducted under water pressures ranging from 4 to 14 pounds per square inch. Each sample was allowed to saturate and permeate for a period of 4 to 6 days before testing.

c. The results of the tests are shown in Table 4-11. The highest permeability measured was 1.06×10^{-7} cm/sec. All other values were in the range of 10^{-8} cm/sec. All of the samples tested are classified as practically impervious[9]. As an illustration, at the highest permeability measured, 1.06×10^{-7} cm/sec. there would be only a permeability of about 3 cm/year (under the laboratory test conditions stated). These test data support the conclusion that there will be virtually no leachates from the ash storage ponds or coal storage area. Groundwater level measurements made on June 19 and October 11, 1975 showed that the depth to groundwater varied from 4.6 feet to 47.7 feet from the lowest point within the ash pond. Using the highest permeability rate of 3 cm/yr, it would take 47.7 years for any water from the ash pond to reach an aquifer located at a depth of 4.6 feet.

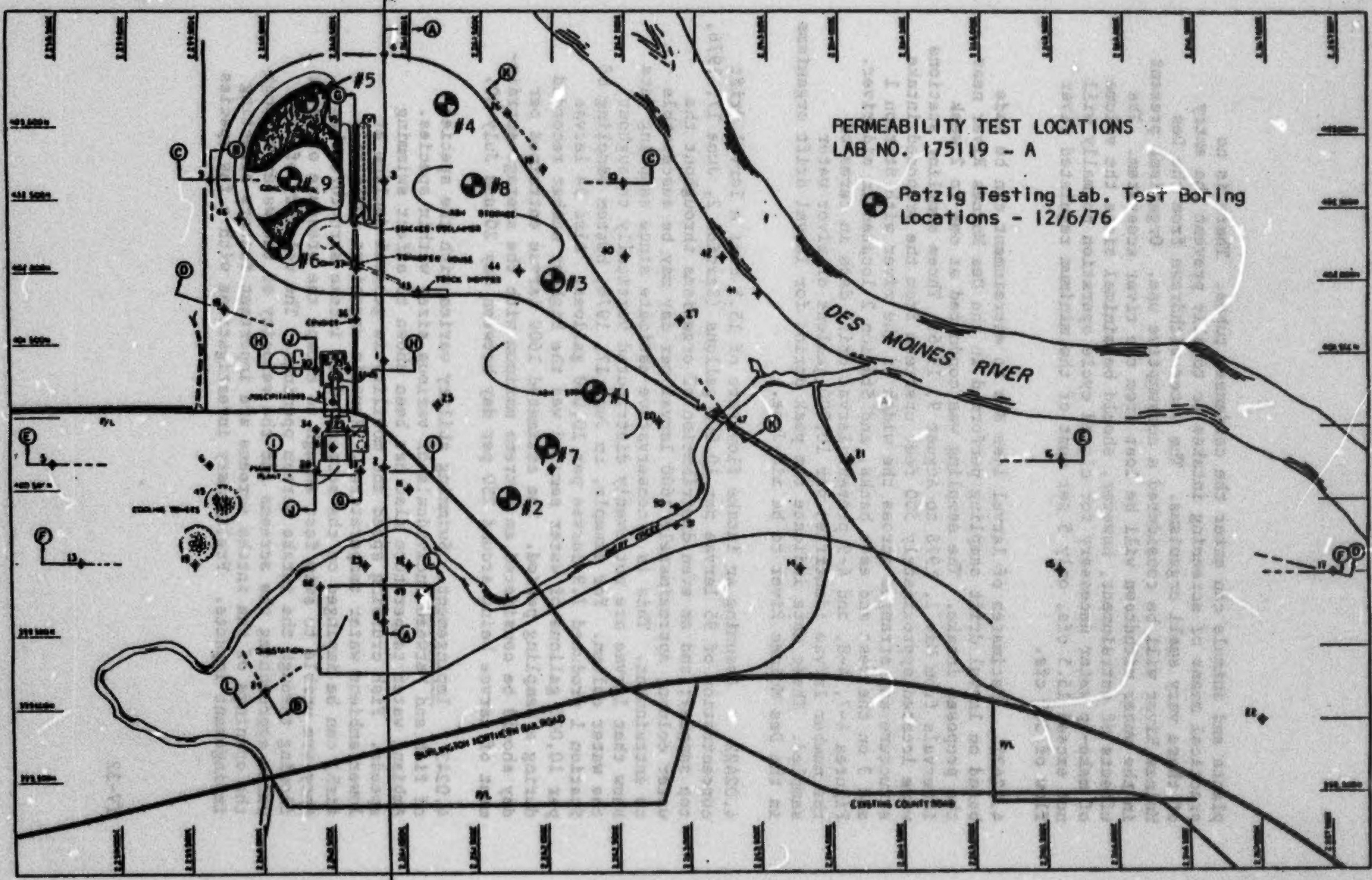
4.0242 Entrainment. Condenser entrainment can involve only those organisms small enough to pass through the meshes of the intake screen. Usually openings of 3/8 inch are used; thus eggs, sac-fry, and other small larval stages of fishes and planktonic

TABLE 4-11

RESULTS OF PERMEABILITY TESTS

Boring	Permeability cm/sec	Material Description	Depth ft
1	1.06×10^{-7}	Dk. Brown, very silty clay	1-2.5
2	2.4×10^{-8}	Gray, silty clay to clay	1-2.5
3	2.1×10^{-8}	Dk. Brown, clayey silt and Dk. Brown to brown, silty and fine sandy clay	1-2.5
4	1.1×10^{-8}	Dk. Brown, clayey silt	1-2.5
5	2.4×10^{-8}	Lt. Gray, mottled brown, silty clay	1-2.5
6	1.3×10^{-8}	Brown, silty clay	1-2.5
7	8.9×10^{-8}	Brown, clayey silt	5-6.5
8	9.3×10^{-8}	Brown, fine sandy clay	5-6.5
9a	5.4×10^{-8}	Gray brown, very silty clay	3-4.5
9b	6.09×10^{-7}	Gray, clayey silt, trace of fine sand	4.5-6

Source: Patzig Testing Laboratory, Des Moines, Iowa, 1976.



SOURCE: ATEC ASSOCIATES

PLAN OF BORINGS
OTTUMWA GENERATING STATION
CHILLICOTHE, IOWA

FIGURE 4-6

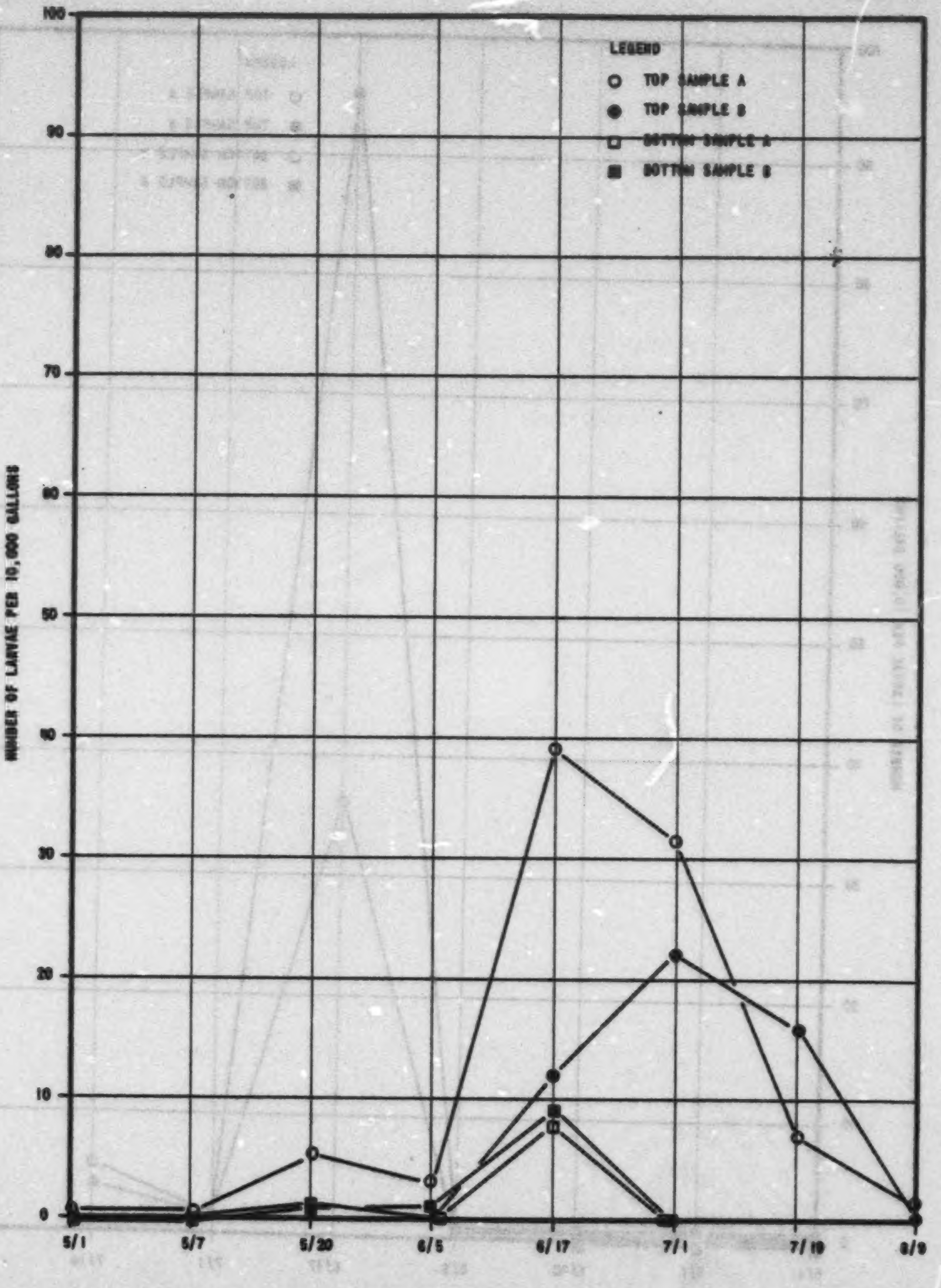
plants and animals can enter the condenser tubes. There is no practical means of screening intakes to totally prevent the entry of these very small organisms. The water withdrawn from the Des Moines River will be considered a consumptive use. Organisms present in the water withdrawn will be lost from the river ecosystem. The effects of entrainment, however, should be minimal since the volume of make-up water necessary for closed cycle operation normally will not exceed 15.5 cfs, only 5 per cent of the minimum regulated river flow of 300 cfs.

4.02421 Estimates of larval loss due to entrainment can be made based on larval drift sampling performed in the Des Moines River near the proposed intake. The sampling was conducted at one to 2 week intervals from May 1, 1976 to August 9, 1976. Three sampling stations were located approximately 500 feet upstream from the proposed intake structure and arranged across the width of the river with Station 1 and 3 on the west and east banks, and Station 2 located in mid-river. Figures 4-7, 4-8, and 4-9 present larval drift data in terms of the number larvae identified per 10,000 gallons of river water sampled. These data indicate the peak period for larval drift organisms in the Des Moines River to be mid-June.

4.02422 Assuming an intake flow rate of 15.5 cfs; a larval drift concentration of 95 larvae per 10,000 gallons (Station 2, June 17, 1976, top sample); and an even distribution of organisms throughout the water column, approximately 1600 larval per day may be susceptible to entrainment. This is a conservative estimate since sampling data show that larvae are not evenly distributed vertically throughout the water column. For example, on June 17, 1976, bottom sampling of Station 1 produced 7.9 larvae per 10,000 gallons. Also 94 larvae per 10,000 gallons of water sampled was the highest number recorded during a sampling period. The estimated 1600 larvae entrained per day should be considered an extreme maximum with the average entrainment of larvae being around 250 per day between May 20 and July 30.

4.0243 Impingement. Swimming ability varies with the species of fish and between individuals of various sizes within species. Ambient water temperature also has been shown to affect swimming speeds. Fish cruising speed and mobility in general decline at lower ambient water temperatures. Aquatic organisms (primarily fish) can be impinged on the screens of an intake structure when they are unable to swim fast enough to escape the pressure of water flowing through the intake screen openings. The velocity of the water approaching the screens and the velocity of the water through the openings of the intake screens are important factors affecting impingement impacts. Preliminary investigations with a few species

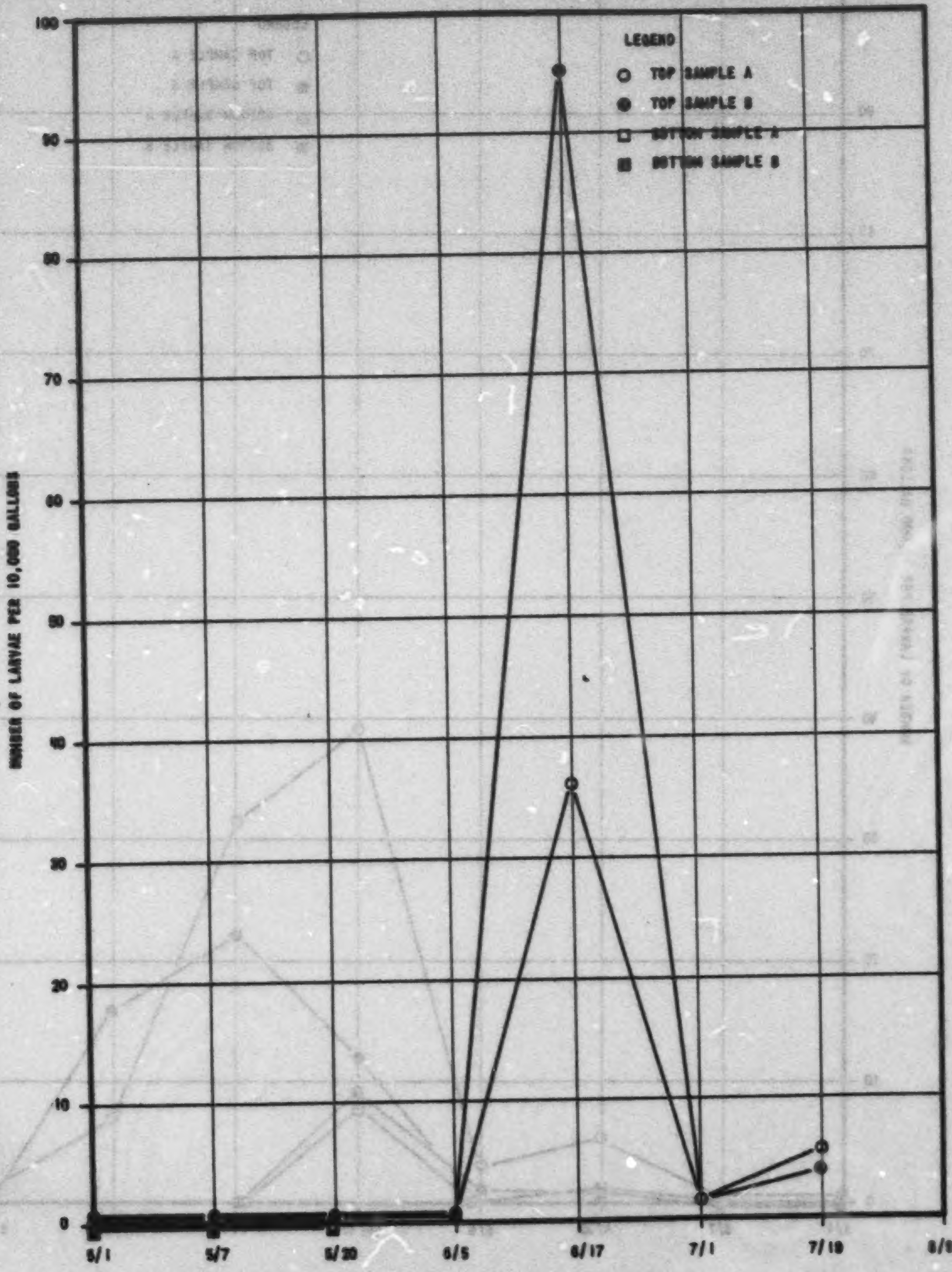
FIGURE 4-7



SOURCE: IOWA INSTITUTE OF HYDRAULIC RESEARCH, 1976

SUMMARY OF FISH LARVAE DATA, STATION I

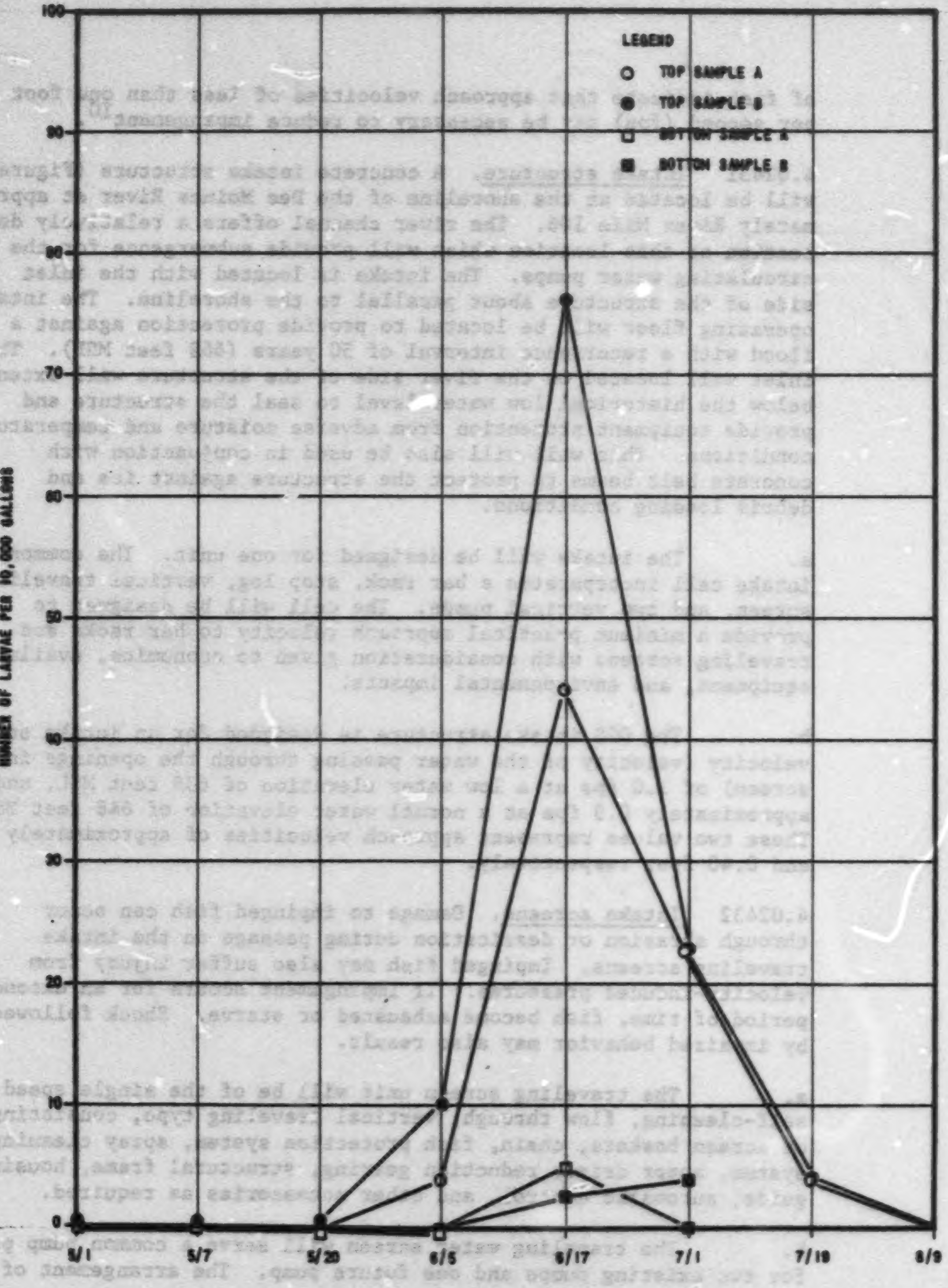
FIGURE 4-8



SOURCE: IOWA INSTITUTE OF HYDRAULIC RESEARCH, 1976

SUMMARY OF FISH LARVAE DATA, STATION 2

FIGURE 4-9



SOURCE: IOWA INSTITUTE OF HYDRAULIC RESEARCH, 1976

SUMMARY OF FISH LARVAE DATA, STATION 3

of fish indicate that approach velocities of less than one foot per second (fps) may be necessary to reduce impingement[10].

4.02431 Intake structure. A concrete intake structure (Figure 4-10) will be located at the shoreline of the Des Moines River at approximately River Mile 106. The river channel offers a relatively deep section at this location which will provide submergence for the circulating water pumps. The intake is located with the inlet side of the structure about parallel to the shoreline. The intake operating floor will be located to provide protection against a flood with a recurrence interval of 50 years (663 feet MSL). The inlet wall located on the river side of the structure will extend below the historical low water level to seal the structure and provide equipment protection from adverse moisture and temperature conditions. This wall will also be used in conjunction with concrete belt beams to protect the structure against ice and debris loading conditions.

a. The intake will be designed for one unit. The common intake cell incorporates a bar rack, stop log, vertical traveling screen, and two vertical pumps. The cell will be designed to provide a minimum practical approach velocity to bar racks and traveling screens with consideration given to economics, available equipment, and environmental impacts.

b. The OGS intake structure is designed for an intake screen velocity (velocity of the water passing through the openings in the screen) of 1.0 fps at a low water elevation of 639 feet MSL, and approximately 0.8 fps at a normal water elevation of 648 feet MSL. These two values represent approach velocities of approximately 0.50 and 0.40 fps, respectively.

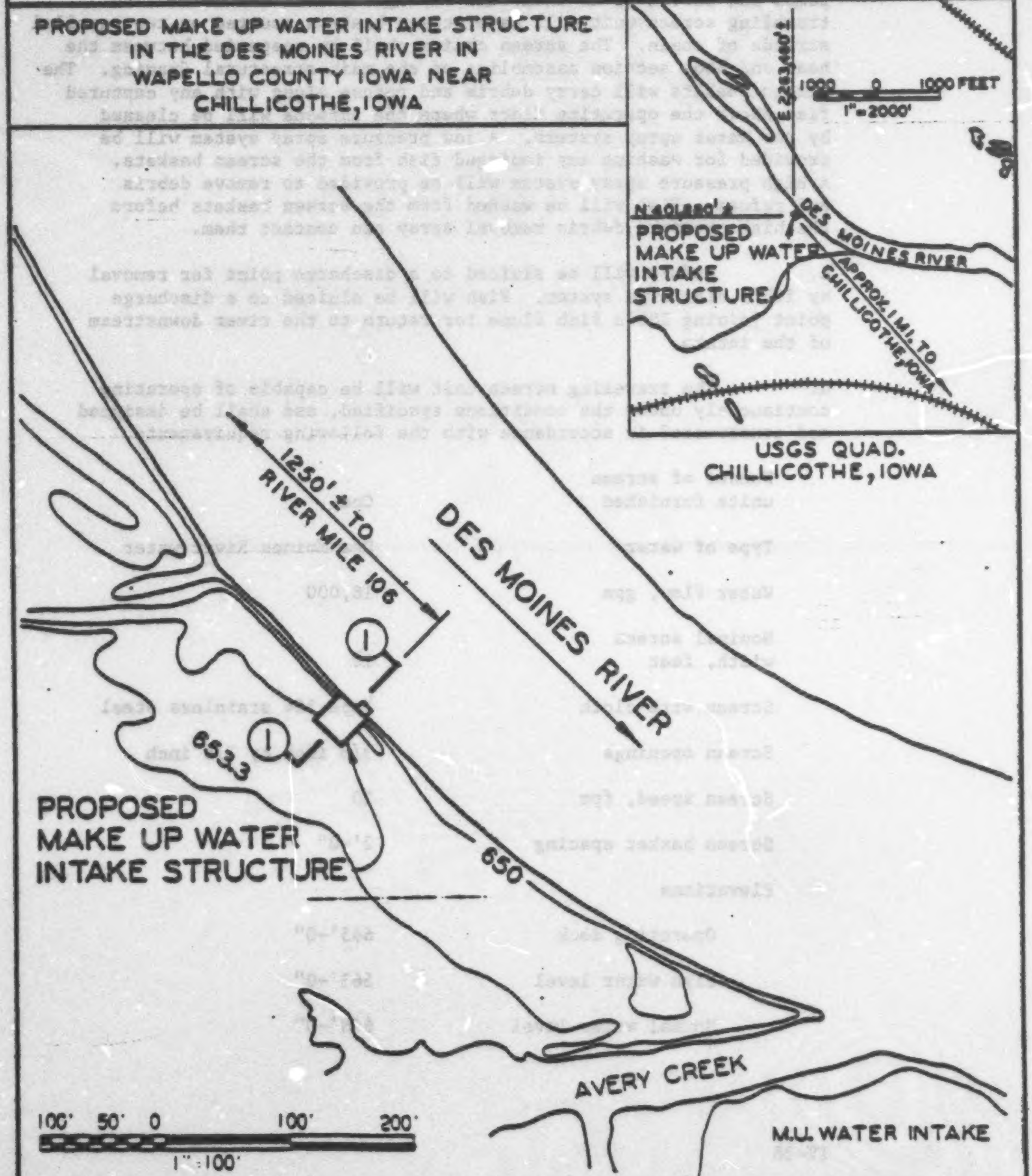
4.02432 Intake screens. Damage to impinged fish can occur through abrasion or dessication during passage on the intake traveling screens. Impinged fish may also suffer injury from velocity-induced pressures. If impingement occurs for an extended period of time, fish become exhausted or starve. Shock followed by impaired behavior may also result.

a. The traveling screen unit will be of the single speed, self-cleaning, flow through, vertical traveling type, consisting of screen baskets, chain, fish protection system, spray cleaning system, motor drive, reduction gearing, structural frame, housing, guide, automatic control, and other accessories as required.

b. The traveling water screen will serve a common pump pit for two existing pumps and one future pump. The arrangement of the

FIGURE 4-10

PROPOSED MAKE UP WATER INTAKE STRUCTURE IN THE DES MOINES RIVER IN WAPELLO COUNTY IOWA NEAR CHILLICOTHE, IOWA


E 2283480'±
1000 0 1000 FEET
1"=2000'
N 401880'±
PROPOSED MAKE UP WATER INTAKE STRUCTURE
DES MOINES RIVER
APPROX. 1 MI. TO CHILLICOTHE, IOWA
USGS QUAD. CHILLICOTHE, IOWA
1250' ± TO RIVER MILE 106
DES MOINES RIVER
1
1
653.3
650
PROPOSED MAKE UP WATER INTAKE STRUCTURE
AVERY CREEK
100' 50' 0 100' 200'
1"=100'
M.U. WATER INTAKE

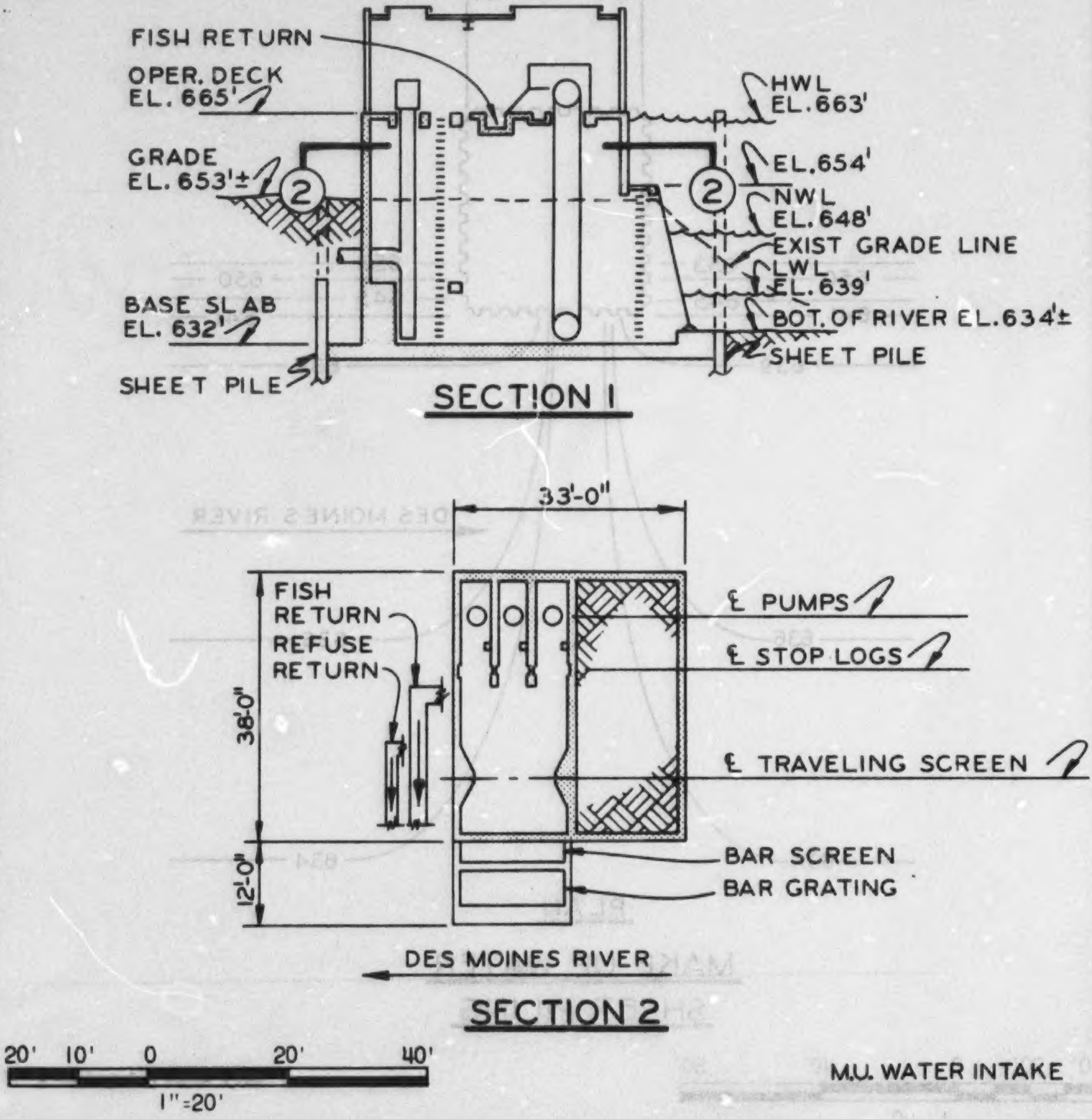
pumps and screen is as indicated on Figures 4-11 and 4-12. The traveling screen unit will have screen baskets mounted on two parallel strands of chain. The screen chains shall be suspended between the head and boot section assemblies of the main structural framing. The screen baskets will carry debris and refuse along with any captured fish above the operating floor where the screens will be cleaned by two water spray systems. A low pressure spray system will be provided for washing any impinged fish from the screen baskets. A high pressure spray system will be provided to remove debris and refuse. Fish will be washed from the screen baskets before the high pressure debris removal spray can contact them.

c. Refuse will be sluiced to a discharge point for removal by ISU's discharge system. Fish will be sluiced to a discharge point joining ISU's fish flume for return to the river downstream of the intake.

d. The traveling screen unit will be capable of operating continuously under the conditions specified, and shall be designed and constructed in accordance with the following requirements.

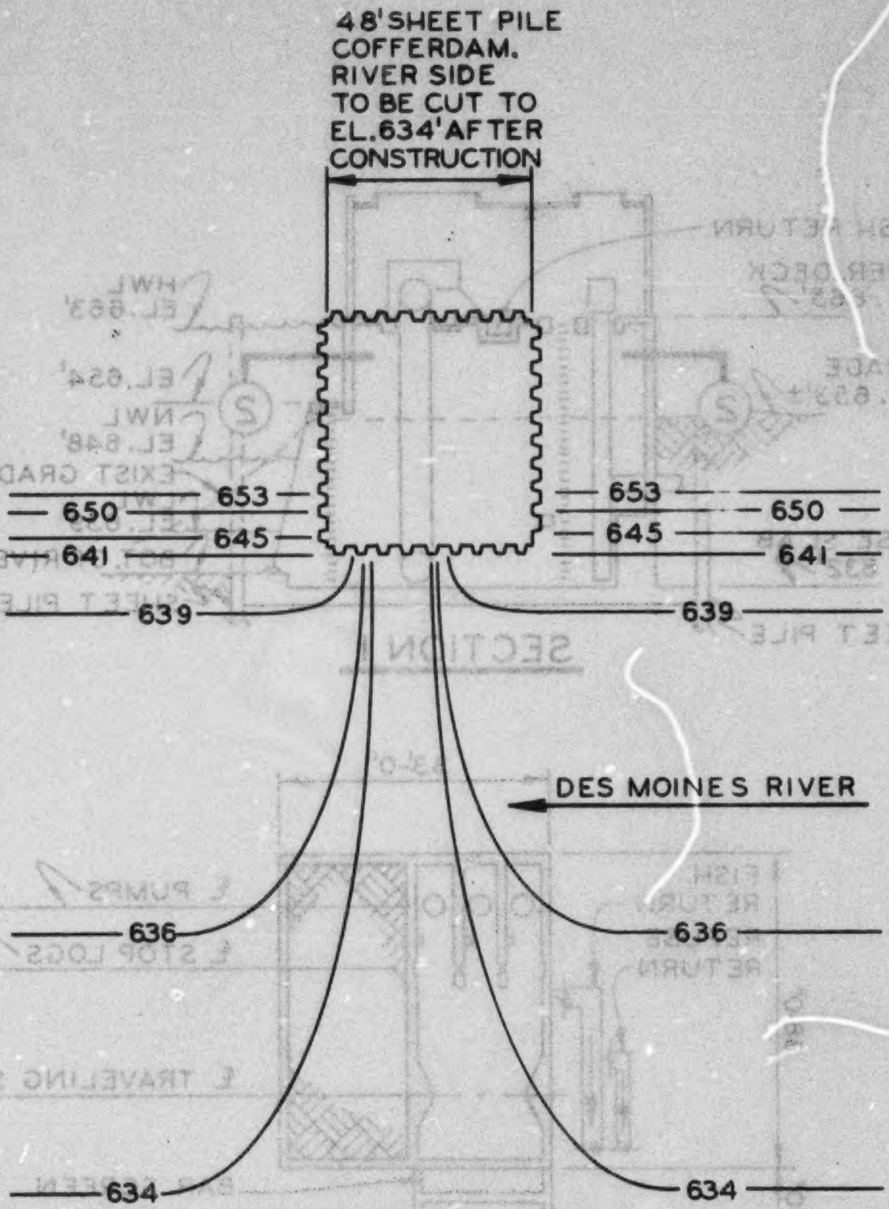
Number of screen units furnished	One
Type of water	Des Moines River water
Water flow, gpm	18,000
Nominal screen width, feet	10
Screen wire cloth	Type 304 stainless steel
Screen openings	3/8 inch by 3/8 inch
Screen speed, fpm	10
Screen basket spacing	2'-0"
Elevations	
Operating deck	665'-0"
High water level	663'-0"
Normal water level	648'-0"

FIGURE 4-11



M.U. WATER INTAKE

FIGURE 4-12



PLAN

MAKE UP WATER
SHEET PILING

40' 20' 0 40' 80'
1" 40'

M.U. WATER INTAKE

Low water level	639'-0"
Bottom of pit	632'-0"

e. The screen baskets will have frames of welded construction provided with curved end plates or shrouds to provide sealing between adjacent baskets and between baskets and the traveling screen boot and frame. The crack width at the seal shall not exceed 1/8 inch.

f. Each screen basket will be furnished with a watertight fish pan or bucket bolted to the bottom basket lip which will provide a minimum water depth in the pan of 2 inches. The bolt holes will be sealed with rubber washers. The upper rear edge of the fish pan, adjacent to the screen wire cloth, will be covered with a rubber shield or other suitable material to reduce fish injury and to prevent fish from being trapped between the screen and the pan.

g. Screening material will be 12 gage type 304 stainless steel wire with 3/8-inch square openings. The screening material will be attached to the screen basket frames in a manner which provides easy replacement of screening material. The screening material will be secured without bolting or clamping bars projecting into the inlet side of the traveling screen unit.

h. A complete high pressure refuse spray cleaning system will be provided with the screen unit. The system will be designed to wash the screen baskets near the top of the unit. The spray nozzles will be of the nonclogging type and will have bores of adequate size to pass any object passed by the traveling screen.

i. The fish protection system will consist of fish pans or buckets, a low pressure spray washing system, and a fish sluice chute to transport the fish to a flume for return to the river downstream of the intake. The spray system will operate intermittently to remove fish from the fish pans. All necessary tripping cams, limit switches, solenoid valves, strainers, pressure reducing valves, shut-off valves, spray nozzles, spray nozzle header, and piping to a supply point common with the refuse spray cleaning system will be provided.

4.02433 Location. Proper location is one of the most important ways to minimize impacts of intake structures[10]. A screen set flush with the face of an intake structure is less liable to trap fish than is one inset in a bay. The OGS intake structure has been located so that Des Moines River currents will tend to sweep any fish past the intake screens. The screen design will also aid in reducing damage to fish that become impinged. Dredging and filling operations during the construction of the intake structure will be in accordance with Section 404, PL 92-500, and subject to Environmental Protection Agency's Guidelines.

4.02434 Impingement problems are expected to be of minimal significance at Ottumwa Generating Station since the design of the intake structure is such that attraction of fish to the intake is not likely to occur. The small volume of water required for closed cycle operation and the fact that the approach velocity to the intake screens will not exceed 1.0 feet per second will further minimize the magnitude of impingement. Figures 4-3, 4-4 and 4-5 show the proposed location and design features of the intake structure. These design features include a vertical traveling screen and a fish return sluiceway to the Des Moines River. These design features, when combined with the low approach and intake velocities, will minimize impingement and entrainment impacts.

4.02435 It is nearly impossible to accurately estimate the magnitude of impingement at the Ottumwa Station since there are no power generating stations similar to the Ottumwa Station presently located on this stretch of the Des Moines River. Preliminary studies at ISU's Eddyville Station 7 miles upstream from the Ottumwa site indicate that impingement is an almost non-existent problem but the Eddyville Station is a far smaller closed cycle facility which currently operates on an intermittent basis. Some fish population data, particularly as is related to relative abundance, is available. Mayhew[11,12,13] conducted three studies of the population dynamics of the river from 1966 to 1968. Studies for the current EIS were also limited to assessing the relative abundance of species present rather than obtaining standing crop estimates, a far more complex and time consuming procedure.

a. Based on the above data, it is possible to arrive at a rough numerical estimate of the probable magnitude of impingement if two basic assumptions are made.

Assumption 1--The combined standing crop per acre for all species in the Des Moines River is similar to the Mississippi River at Quad-Cities, although the relative abundance is different.

Assumption 2--The composition of the fishery of the Des Moines River is still similar to that observed by Mayhew, which is generally consistent with the studies of relative abundance for the OGS ER.

b. Studies conducted by Commonwealth Edison Co.[13] at the Quad-Cities Station have provided extensive data on the standing crop of the Mississippi River and the magnitude of impingement at the station. It is evident from these data that relative abundance and swimming speed are not the major factors influencing the impingement of various species. Other factors such as schooling behavior and the propensity for attraction to warm waters must also be considered. For example, although gizzard shad account for only 22 per cent by weight of the standing crop of the Mississippi River, they made up almost 90 per cent by weight of the fish impinged in 1973. Similarly, carp which account for approximately 18 per cent of the standing crop made up only 0.4 per cent of the total impingement by weight in 1973. Thus it is possible, assuming similar propensity for impingement of a given species on the Des Moines and Mississippi Rivers, to calculate the relative magnitude of impingement expected with variations in abundance of different species. Since the volume of water entering the station will also influence the impingement numbers, the effect of this parameter on the expected magnitude of impingement can be predicted.

c. The following has been used to estimate the magnitude of impingement expected at the Ottumwa Station (Table 4-12).

Column A--Lists the significant species of fish found in both rivers.

Column B--Gives the per cent by weight of the estimated standing crop for each species at Quad-Cities as determined by the Commonwealth Edison studies.

Column C--Gives the pounds of each species removed by impingement at Quad-Cities in 1973.

d. These low values are in accordance with the impingement results from the Duane Arnold Energy Center, a closed cycle nuclear generating station located on the Cedar River which withdraws 24.5 cfs (maximum) of makeup water. Studies conducted at this station during 1974 and 1975[14,15] indicate that frequently no fish whatsoever are impinged during a 24-hour period and the maximum number of fish impinged within a 24-hour period was 33 with a combined weight of less than one-half pound. Young-of-the-year channel catfish were the form most commonly impinged at the Duane Arnold Energy Center.

e. Regarding periods of maximum impingement it is likely that for most species (particularly gizzard shad, drum, catfish and white bass) young-of-the-year individuals will be impinged

TABLE 4-12

SUMMARY OF IMPINGEMENT DATA AT QUAD-CITIES (1973) AND PROJECTED IMPINGEMENT AT OTTUMWA GENERATING STATION.

A Significant Fish Species (both river systems)	B % (by wt.) of standing crop Mississippi River	C Removal (pounds) by impingement at Quad-Cities in 1973[1]	D % of total impingement (by wt.) at Quad-Cities for each species[1]	E % relative abundance (by wt.) of fish species - Des Moines River (1968 & 1975)2,3	F Estimated standing crop per acre in Des Moines River (Col. E x 397 lbs. per acre)	G Expected removal (lbs.) at Quad-Cities if relative abundance similar to Des Moines River (E/B) x C	H Expected removal at Ottumwa (lbs/yr) (G ÷130)
Carp	18	385	0.4	18[2]	72	385	2.9
Carp-sucker	18	136	0.1	26[2]	103	196	1.5
Gizzard Shad	23	93,865	90.4	0.5[3]	2	2,040	15.7
Drum	8	3,459	3.3	0.4[3]	2	173	1.3
Channel Catfish	4	901	0.9	50[2]	198	11,262	87
White Bass	0.2	490	0.5	0.2[3]	1	490	3.8
Other*	28.8	4,590	4.4	4.9	19	781	6.0
Total		103,826					118.2

*Others include buffalo, walleye, bluegill, crapple, northern redhorse

1. Commonwealth Edison Co. 316(b) (1975)
2. Mayhew, Jim, 1969, Report on the Third Year Study of Commercial Fish Species in the Des Moines River and Coralville Reservoir, Biology Section, Commercial Fisheries Report, Project 4-11-R-3.
3. Ottumwa EIS, Fishery Data (1975)

following spawning periods. Based on the Quad-Cities studies it is likely that most gizzard shad will be impinged during the September-January period, especially if recirculation of heated water into the intake structure is necessary. Gizzard shad are commonly attracted to warm water areas during the winter months and are particularly prone to impingement due to their slow swimming speeds. Channel catfish impingement has also been observed to increase during the fall and winter periods. Impingement of drum at Quad-Cities was generally found to be highest in early spring and early fall.

4.025 Economic and Social Effects

4.0251 Introduction. The direct and indirect effects of the operation of OGS and corresponding impacts on the projected levels of economic activity in the Primary Area are considered in this section. These effects will commence upon completion of the construction phase in 1981 and will continue as long as OGS is in operation. The economic and social impacts of the project in the Primary Area are determined by comparing the "with OGS" and "without OGS" projections of economic activity. All operation phase cumulative impacts are shown in Table 4-13. The results of the operation of OGS which generate impacts in the Station Site, Primary Area and Secondary Area include the manpower necessary to run the plant, staff payrolls and property tax revenues in the Station Site, Primary and Secondary Areas. These direct effects of operation create additional indirect effects in the form of stimulated regional economic activity. Changes in the levels of personal income, employment, and property tax revenues caused by the operation of OGS create additional indirect impacts on the regional economy.

4.0252 Direct operation effects. As discussed in Section 4.0241, direct effects of the operation of OGS in the Primary Area include increased personal income due to permanent staff payrolls, additional employment caused by the need for operating personnel and more property tax revenues generated by the inclusion of OGS capital investment in the tax base. The magnitude of these effects is reflected in Table 4-14. It should be noted that most of the additional jobs created by the operation of OGS will be filled by local residents. Outside of the Primary Area the only significant effect of the operation of OGS will be on property tax revenues. The increased property tax base will generate additional revenues which benefit the Secondary and External areas. The magnitude of these revenues is indicated in Table 4-14.

TABLE 4-13

CUMULATIVE DIRECT AND INDIRECT ECONOMIC IMPACTS DURING OGS OPERATION (1982-2010) 1981 DOLLARS

	Impact	Percentage Increase Due to OGS Impact
Employment, Man-Years	1,856	0.15
Personal Income	43,413,000	0.25
Wages & Salaries	38,048,000	0.43
Profit & Proprietor Income	5,365,000	0.09
Disposable Income	40,745,000	0.26
Federal Income Tax Revenues	1,720,667	0.16
State Income Tax Revenues	942,500	0.36
Retail Sales	7,472,333	0.10
Retail Sales Tax Revenues	275,500	0.11
Bank Deposits, $-Years	3,765,167	0.03
Farm Income	-3,694,167	<0.27>
Real Estate Sector (APV, REV, PSV, VFLB)	Positive Impact	*
Property Tax Revenues (Direct and Indirect)	Positive Impact	*

*Not available.

TABLE 4-14

DIRECT OPERATION EFFECTS WITH OGS

Average Annual Permanent Staff Payroll (1981 $)	$ 976,206
Annual Employment, Man-Hours	$ 100,000
Estimated Annual Property Tax Revenues* in Station Site (1981 $)	$1,230,000
Estimated Annual Property Tax Revenues* in Secondary & External Areas (1981 $)	$7,999,000
Annual Value of Cropland Removed from Production	$ 125,830
Inflated Annual Value of Cropland Removed from Production (1981 $)	$ 158,495

*See Table 4-2, Property Tax Revenues, 1982.

4.02521 Loss of crop production on station site. Previous owners of site acreage were allowed to continue farming in 1975. A total of 301 acres of corn and 147 acres of soybeans were planted. The approximate remaining balance of the 795 acres consists of 88 acres of hay meadow and 259 acres of rough pasture woodlands. Present plans are not to disturb the land containing 77 acres of corn and 45 acres of soybeans during the OGS operating life. All other production will be eliminated. Therefore, crop losses based on 1975 production will equal 224 acres of corn, 102 acres of soybeans, and 88 acres of hay meadow. The Wapello County Extension Service, Iowa State Agriculture Department, suggests a value of $420/acre for corn, $260/acre for soybeans, and $30/acre for hay meadow; with a grazing value of $10/acre for the balance of the acreage. Annual crop loss in 1975 dollars would then be $94,080 for corn, $26,520 for soybeans, $2640 for hay meadow, and $2590 for rough pasture; a total of $125,830.

4.02522 Dislocation of site residents. There are presently two families and one single person living on the site, totaling 11 persons. All of these residents must relocate. No other dislocations will be required.

4.0253 Indirect operation effects. The indirect effects of the operation of OGS are a result of increased economic activity due tó permanent operating staff payroll multiplier effects in the Primary Area. All of the other indirect operation phase impacts shown in Figure 4-2 result from the permanent crew, their families, and the income and expenditures made by them. The indirect operation impacts represent a small portion of projected economic activity and are virtually insignificant.

4.02531 In its 1975 Areawide Overall Economic Development Plan, the Area XV regional planning commission discusses the expansion of industrial facilities in its planning district. It is their hope that enough additional industry can be attracted into the area in order to support the desired rate of economic growth. Since proximity to a power source does not result in lower electric rates, it is not expected that the location of OGS in the area will stimulate industrial development in any way other than simply expanding the capacity of the entire ISU system.

REFERENCES

1. Office of Noise Abatement and Control, *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, 550/9-74-004, U.S. Environmental Protection Agency, Washington, D.C., March 1974, p. 3.

2. Bolt, Beranek, and Newman, *Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances*, NTID 300.1, U.S. Environmental Protection Agency, Washington, D.C., December 31, 1971, p. A-1, A-39.

3. Ibid, pp. B-6 to B-11.

4. Office Noise Abatement and Control, *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety*, #550/9-74-004, U.S. Environmental Protection Agency, Arlington, Virginia, March 1974, p. 3.

5. Ibid., p. 4.

6. Office of Noise Abatement and Control, Ibid., pp. 21-22.

7. Office of Noise Abatement and Control, *Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances*, NTID 300.1, U.S. Environmental Protection Agency, Washington, D.C., December 31, 1971, pp. B-8 to B-10.

8. L. L. Beranek, ed., *Noise and Vibration Control*, McGraw-Hill, Inc., New York, 1971, pp. 182-184.

9. Davis, S. N. and R. J. M. DeWeist, *Hydrogeology*, John Wiley & Sons, Inc., p. 164, 1966.

10. U.S. Environmental Protection Agency, 1973, Development Document for Proposed Best Technology Available for Minimizing Adverse Environmental Impact of Cooling Water Intake Structures, U.S. Environmental Protection Agency.

11. Mayhew, J. and Mitzner, L., 1967 "Report on the First Year Study of Commercial Fish Species in the Des Moines River and Coralville Reservoir," Biol. Sec. Commercial Fisheries Report, Ia. Cons. Comm. Proj. 4-11-R-1.

REFERENCES (Continued)

12. Mayhew, J. and Mitzner, L., 1968, "Report on the Second Year Study of Commercial Fish Species in the Des Moines River and Coralville Reservoir," Biol. Sec. Commercial Fisheries Report, IA. Cons. Comm. Proj. 4-11-R-2.

13. Mayhew, J. and Mitzner, L., 1969, "Report on the Third Year Study of Commercial Fish Species in the Des Moines River and Coralville Reservoir," Biol. Sec. Commercial Fisheries Report, IA. Cons. Comm. Proj. 4-11-R-3.

14. Commonwealth Edison Co. (1965) "Three-Sixteen a and b Demonstration - Quad-Cities Nuclear Station-Mississippi River," submitted to the U.S. EPA November 1975.

15. McDonald, D. G., "Cedar River Baseline Ecological Study Annual Report - January 1974-1975," report submitted to Iowa Electric Light and Power Company, August 1975.

16. McDonald, D. G., "Cedar River Baseline Ecological Study Annual Report - January 1975-January 1976," report submitted to Iowa Electric Light and Power Company, April 1976.

V PROBABLE ADVERSE ENVIRONMENTAL IMPACTS WHICH CANNOT BE AVOIDED

5.01 Impacts of Construction Activities.

5.011 Terrestrial Environment. There will be a loss of some forest and grassland which presently provide habitat for mammals, birds, herptiles, insects, and invertebrates. There will be a permanent distruption of normal succession and changes in ecological recycling and productivity. Most of the 795 acre site that is presently utilized for agricultural purposes will be diverted to industrial use; i.e. production of electrical energy. The presence of the generating station will distract to some extent from the aesthetic character of the predominantly rural area.

5.012 Water Quality and Biological Elements. Some erosion and stream siltation could occur as a result of clearing and grading although good engineering practices will be carried out to reduce the possibility. Temporary increases in the turbidity of Avery Creek and along the shoreline of the Des Moines River could reduce the productivity of photosynthetic organisms; however, the effect should not be significantly different from that of runoff from cultivated land.

5.0121 The construction of the intake structure also could briefly increase slightly the turbidity of the Des Moines River near the Station Site.

5.013 Air Quality. There will be some dust generated from construction activities. Combustion gases will be discharged from construction vehicles and machinery working on the site.

5.014 Social and Economic Impacts. Two families and one single resident totaling 11 persons will be relocated from the Ottumwa Station Site. Based on 1975 dollars, an annual crop value of $125,830 will be lost because of the conversion of the site from agricultural purposes to industrial use. There will be increased traffic in the plant site area during the construction period.

5.02 Impacts of Generating Station Operation.

5.021 Air Quality. The level of certain air pollutants is expected to increase when the Ottumwa Station is in operation. The concentrations of sulfur oxides, nitrogen dioxide, ozone, and particulate matter would increase. Emission of pollutants from the station will be minimized by the burning of low-sulfur content coal and the use of a tall stack to enhance the dilution of emission gases. All air quality standards will be met.

5.022 Water Quality and Biological Elements. Wastewater discharge will be monitored in accordance with applicable regulations and there should be little adverse impact on the water quality of the Des Moines River.

5.0221 Water withdrawn from the Des Moines River for cooling water make-up and other uses (maximum rate of 20 cfs) will constitute a consumption use and organisms present in the water will be lost from the river ecosystem. The effects of entrainment should be minimal because the volume make-up water normally will not exceed 17.2 cfs, about 5 per cent of the minimum regulated river flow of 300 cfs.

5.0222 Some fish may become impinged on intake screens and injured or killed, but efforts to alleviate these effects would be made by careful design, and placement of the intake structure together with a flow approach velocity to the intake screens of only 1.0 feet per second or less.

5.0223 Economic and Social Impacts. No adverse economic impacts are expected from the operation of the Ottumwa Generating Station. The presence of the tall stack and the station facility will detract from the aesthetic appeal of the area. Noise from the station operations would be largely dissipated at the site boundary, but may add slightly to the ambient level of the surrounding area.

VI ALTERNATIVES TO THE PROPOSED PROJECT

6.01 No Action. One alternative would be not to construct and operate the Ottumwa Generating Station. Without the 727 MW station, ISU and the other owners would be unable to meet projected energy demands in their service areas (see Section 1.02). Electric power deficiencies will occur in the latter part of this decade without the Ottumwa Station.

6.011 Iowa utilities are required by law to provide adequate service to their customers. The generating capacity of a utility's plant, supplemented by the electric power regularly available from other sources, must be sufficiently large to meet all normal demands for service and provide a reasonable reserve for emergencies[1].

6.012 Assuming that restricting service would be an alternative to the Ottumwa Station, it is evident that without increased generating capabilities the operations and growth of industrial, commercial and household customers would have to be curtailed. An evaluation of the social and economic effects that would result is beyond the scope of this study.

6.013 Because of legal requirements and the adverse consequences of restricting the use of electric energy, the alternative of not providing increased generating capacity; i.e. construction and operation of the Ottumwa Generating Station, is not feasible.

6.02 Purchase Power. It is unlikely that significant amounts of power will be available for long-term purchase. The owners of the Ottumwa Generating Station are members of the Mid-Continent Area Power Pool (MAPP); however, MAPP only provides a mechanism for supplying power primarily during emergencies and for frequency stability. Large blocks of power cannot be obtained consistently for extended periods.

6.021 It is not practical to purchase power in other parts of the country and transmit the electric energy to Iowa. Transmission losses vary directly with distance and with the square of the amount of power transmitted. Considerable power loss would occur in transmitting electric power over long distances, and the cost would be significantly more than the cost of locally produced power.

6.022 The purchase of power as an alternative to the Ottumwa Station is not practical.

6.03 Alternate Methods of Generation

6.031 Combustion Turbines. Combustion turbines are useful in generating power during peak loads and for other short-term applications. The units are not suitable for continuous operation, they are inefficient, and they require frequent maintenance. In addition, combustion turbines burn gas or fuel oil, both of which are in short supply and are becoming more expensive.

6.0311 Combustion turbines would not be suitable to satisfy long-term base load energy requirements.

6.032 Hydroelectric Generation. There are no suitable sites for hydroelectric power generating stations that would meet the base load requirements of ISU and the other utility companies involved.

6.0321 Pumped storage projects also would not be feasible because of the lack of suitable sites for plants to meet base load requirements.

6.04 Alternate Fossil Fuels

6.041 Natural Gas. Natural gas is a relatively clean burning fuel that could be considered as an alternative to coal. Unfortunately, there is a national shortage of natural gas, and about 7,010,000 cubic feet an hour of gas would be required to operate the Ottumwa Station at full load. There are no suppliers that would contract to provide that quantity of natural gas. Most suppliers are refusing to sell gas to new large nonresidential customers, and in many instances will not increase deliveries to present consumers.

6.0411 Because of the shortage of natural gas and its general unavailability to new large industrial users, it was rejected as an alternative to coal as fuel.

6.042 Synthetic Gas Fuel. Although processes for producing synthetic gas are being developed, the technology is not presently available to produce an adequate fuel supply for the Ottumwa plant.

6.043 Fuel Oil. The supply of fuel oil is limited and the cost would be at least twice as much per Btu produced as compared to low-sulfur coal.

6.0431 Furthermore, Federal Energy Administration will not permit the use of oil as fuel for steam generating stations.

6.044 Iowa Coal. One of the first alternatives considered was the obvious one of Iowa coal. The use of an Iowa supply would minimize transportation costs and reliability problems and has the further advantage of providing employment and economic activity to the State of Iowa.

6.0441 The Iowa Coal Project, funded by the State of Iowa and carried out at Iowa State University, has started a detailed and extensive study of Iowa coal reserves, mining methods, and sulfur removal techniques. Reserves of some 6 to 7 billion tons have been identified, indicating that a large amount of Iowa coal could be mined. This coal generally runs 10,000 to 11,000 Btu per pound with a sulfur content of 3 per cent to 7 per cent. Approximately half of the sulfur can be removed by a washing process which would leave sulfur in the 1-1/2 per cent to 4 per cent range. According to the EPA New Source Performance Standards the maximum sulfur content for 10,000 Btu coal is 0.6 per cent. Therefore, the use of Iowa coal would require the installation of a flue gas scrubber at an additional capital cost of approximately $40,000,000 and additional operating cost of $.55 per million Btu.

6.0442 Although plentiful, Iowa coal lies in seams of 2 feet to 4 feet and at depths of over 100 feet. These seams are difficult and expensive to mine by either strip or underground processes. AMAX Coal Co. has made an extensive study of mining in Iowa and estimates the cost of such coal at $25 per ton at the mine. Costs of Iowa coal summarize as follows:

Cost of coal at mine	$25.00
Transportation to OGS	1.50
	$26.50/ton
For 10,000 Btu coal this is equal to	$ 1.33/MM Btu
Scrubber operating costs	.55/MM Btu
Total Fuel Costs:	$ 1.88/MM Btu

6.0443 Only about 1,000,000 tons per year of Iowa coal are presently mined which would not be adequate to operate the Ottumwa Generating Station[2]. Initially the Ottumwa Station will use about 2,200,000 tons per year of coal.

6.0444 Because of economic considerations, an inadequate supply presently available, and high sulfur content, Iowa coal is not a viable alternative as a fuel source for Ottumwa Station.

6.045 Missouri, Illinois, Kentucky, and Other Midwestern Coal. In exploring other Midwestern coal supply possibilities, it was found that no Midwestern supply exists which will meet the New Source Performance Standards without the use of a flue gas scrubber.

6.0451 Although some economies of scale exist in the larger mines in Illinois and Kentucky, it would take a commitment of new capital and in most cases the opening of a new mine to meet the 2,200,000 ton per year requirement for OGS. The quoted costs of strip mined coal throughout this Midwestern region is in the $20 to $25 range with underground mined coal substantially higher. Estimated costs for this fuel supply are:

Cost of coal at the mine	$20.00
Transportation to OGS	3.00
	$23.00
For 10,000 Btu coal this is equal to	$ 1.15/MM Btu
Scrubber Operating Costs	.55/MM Btu
Total Fuel Costs:	$ 1.70/MM Btu

6.046 Western Coal. An investigation of low sulfur Western coal sources revealed that coal quality, availability, and prices varied widely. Distances in the West are great, leading to considerable variation in freight costs.

6.0461 Initially it appeared that the lowest cost source of low sulfur, EPA compliance fuel (under 0.5 per cent sulfur) would be the Powder River Basin near Gillette in northwestern Wyoming. Mining conditions in that area lead to the lowest cost production in the United States. The coal seams there are 70 feet to 100 feet thick and lie under as little as 30 feet of overburden. Coal was being sold from the AMAX mine in 1972 for under $2.00/ton at the mine.

6.0462 By late 1973, however, environmental interests had effectively stopped mine development in that area and there was no certainty that coal could be delivered to meet the 1980 time schedule for OGS. Therefore, while maintaining contact with the oil interests which held coal reserve leases in the Powder River Basin, the search was broadened to other supplies of Western coal.

6.0463 Existing mines or proposed mines in other parts of Wyoming and Colorado were found which were not subject to the environmental restrictions of the Powder River Basin and which could guarantee delivery of coal to meet OGS requirements. This coal, however, came from underground or deep open pit mines which cannot match the low mining costs at Powder River. Thus, early cost estimates and the decision to concentrate on Western coal were based on higher cost estimates than those which will apply to Powder River coal.

6.0464 Recently, rapid developments have occurred in Western coal mining. The U.S. Supreme Court has lifted the injunction preventing further mine development and a decision on the requirement of a six state environmental impact statement will be necessary before mining or railroad construction can begin. All indications are that this decision will be favorable to the mining interests. As a result mines are once again under construction and coal supply contracts are being offered.

6.0465 The following cost quoted is a worst case example and is a major reason for concentration on Western coal as the best alternative fuel source for OGS.

Cost of coal at mine	$14.00
Transporation to OGS	10.00
	$24.00
For 8,000 Btu coal this is equal to	$ 1.50/MM Btu
Scrubber operation costs	—
Total Fuel Costs:	$ 1.50/MM Btu

6.05 Nuclear Fuel Source. Since from 8 to 10 years are required to construct and place in operation a nuclear power station, it would not be possible to have the necessary generating capability by 1981.

6.051 Only about 4 years will be required to place the Ottumwa Generating Station in operation.

REFERENCES

1. Code of Iowa, Sections 490.8 and 490A.26. (1973).

2. Iowa Geological Survey, Resource Development, Land- and Water-Use Management, Eleven-County Region, South-Central Iowa, Iowa City, Iowa (1973).

6.06 Alternate Modes of Fuel Transportation

6.061 Barge Transportation. Transportation of the plant's coal fuel will be by rail; however, other methods were evaluated. One alternative method considered was to transport the coal by barge on the Des Moines River. This method was found to be impractical. The Des Moines River is not large enough to maintain its flow within certain limits of channel depth. Presently, there are no lock and dam installations to maintain channel depth and produce an artificially regulated, navigable Des Moines River.

6.062 Coal Slurry Pipeline. One possible method for transporting coal to the site is by pumping crushed coal with slurry water through an underground pipeline from the coal mine to the power plant. There are no coal slurry pipelines in the vicinity of the proposed generating station nor are there plans to construct any.

6.07 Alternate Plant Sites

6.071 Introduction. In studies conducted by Black & Veatch and ISU, a number of sites were evaluated as to their suitability for locating and operating a steam generating station.

6.072 Candidate Site Selection

6.0721 Candidate sites were screened and selected by meeting the following considerations.

6.0722 Service area. The candidate sites should be in close proximity to the ISU service areas.

6.0723 Land area and use. A minimum of 600 acres of land will be required for the project. Current and projected land use practices must be compatible with the construction and operation of a 727 MW unit installation.

6.0724 Water supply. A reliable source of water must be available for use. The source should be capable of supplying an estimated 20 cfs of water for continuous cooling tower makeup and other plant uses.

6.0725 Transportation access. All candidate sites must have close proximity to transportation networks--railroad, highway, and/or barge; or be capable of their development for shipment of materials and use by construction workers and personnel.

6.0726 Transmission access. The site should be located near existing or proposed transmission lines and substations.

6.0727 Population. Those sites that are located away from population areas or centers will be given priority.

6.0728 Electric load. The sites should be located near the load center.

6.0729 Flood protection. Sites having adequate flood protection or the potential for development at a reasonable cost were considered.

6.07210 Environmentally sensitive areas. Candidate sites will be screened for possible interference with the following.

a. Any local, state or federal park and reserve; rec reational and other public use areas.

b. Archaeological, historical, or cultural landmarks.

c. Rare or endangered fauna or flora species including their habitats and breeding and/or nesting areas.

6.073 Site Selection Process

6.0731 Investigative studies were performed and the number of sites considered was narrowed to four—the Bridgeport site at Eddyville, the Burlington site and two sites near Chillicothe, (Sites F and G). The other sites were found to be unsuitable. ISU's service region and the already existing Bridgeport and Burlington plants and the area for Sites G and F around Chillicothe are shown in Figure 1-2 (Section 1). The arrangement of Sites F and G are shown in Figure 6-1.

6.0732 Criteria for the final selection of the site were as follows.

6.0733 Evaluations should include a unit of approximately 350 MW gross and a unit of 600 MW gross.

6.0734 Facilities should be based on the use of a low sulfur western coal as well as a high sulfur coal.

6.0735 The site should provide space for storage of 90 days supply of coal and for 25 years ash storage, assuming no gas scrubbing.

6.0736 Siting considerations should take into account the existing plant facilities at Bridgeport and Burlington and the effect that new facilities would have on any requirements for retrofitting the existing equipment to meet pollution requirements.

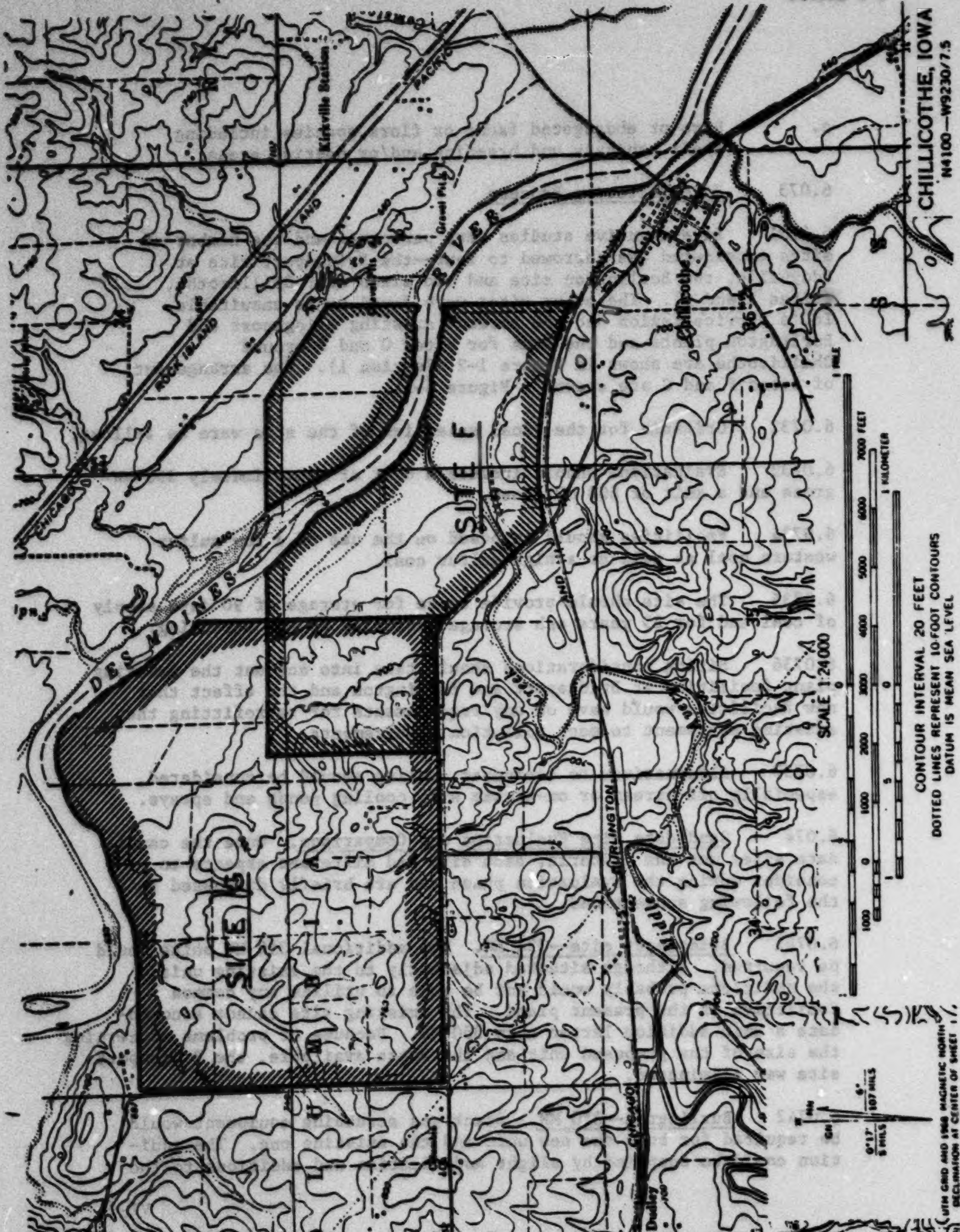
6.0737 Alternatives to condenser cooling should be considered, especially off-stream or on-stream with cooling ponds and sprays.

6.074 Candidate Site Evaluation and Comparison. Once the candidate sites met the criteria, each site had different aspects to consider during the evaluation phase and are briefly discussed in the following subsections.

6.0741 Bridgeport site—350 MW. Two additional 350 MW units would be required. Although situated adjacently to the existing unit, the additions probably would not be able to utilize any common facilities of the present plant. The existing site cannot accommodate a unit addition larger than 350 MW. Because of problems concerning the size of the proposed unit and the space available, the Bridgeport site was eliminated.

6.0742 Burlington—350 MW. Stack gas scrubbing equipment would be required for both the new unit and the existing one. The addition could be supplied by slight modification and additions to the

FIGURE 6-1


CHILLICOTHE, IOWA
N4100—W9230/7.5
SITE F
SITE G
DES MOINES RIVER
ROCK ISLAND
CHICAGO
PACIFIC
Kirkville Station
Chillicothe
BURLINGTON
Middle
Avery Creek
Dudley
SCALE 1:24000
1 MILE
7000 FEET
1 KILOMETER
CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL
UTM GRID AND 1960 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

existing coal handling system. Utilization of a common control room facility for both units would be possible. Canal type condenser cooling would not be possible due to the low terrain and extensive earth-fill required. This site was eliminated because of the additional costs involved with the scrubbing equipment for both the new and existing units and because of the modifications and additions that would be necessary for the coal handling system.

6.0743 Burlington--600 MW. There is not sufficient space on the site for all the coal, ash and stack scrubbing facilities which would be necessary. Because of the large size, it would not be possible to have the unit located as an adjoining addition to the existing unit. This site was considered unacceptable for these reasons.

6.0744 Site F--600 MW. The layout has been developed on unit train type of coal delivery. Space consideration would be involved with stack gas scrubbing equipment; however, elimination of this equipment would be possible by use of a hot electrostatic precipitator and by dispersion by a tall stack. With the use of a low sulfur western coal, it would be possible to satisfy emission standards.

6.0745 Site G--600 MW. Requirements for scrubbing and coal storage have been included, assuming coal arrival by unit train. Arrangement would be modified if stack gas scrubbing was not required. Considerations for Sites F and G were basically the same with the exception of the land acquisition and the site arrangement.

6.0746 Table 6-1 is an evaluation and comparison table that lists the siting considerations for the alternate plant sites. Land acquisition, site accessibility and versatility, substation requirements, emission control, coal handling, circulating water, estimated cost, and any archaeological, historical, or cultural landmark were assessed for each site.

6.0747 In addition, sites were screened for population centers within a 5-mile radius. Figures 6-2, 6-3, and 6-4 show the population centers around Burlington, Bridgeport, and the Chillicothe sites. Table 6-2 lists the towns, the county in which they are located, and the population estimates if available.

6.075 Conclusion

6.0751 The site chosen for the construction of the Ottumwa Generating Station is adjacent to the Des Moines River on the north side and to the town of Chillicothe on the southeast edge in Wapello County, the Columbia-Cass Township. The current site constitutes

Table 6-1

SITE COMPARISON TABLE

Capacity Location Fuel (New Unit) Fuel (Existing Unit)	350 MW Bridgeport Wyoming Coal	350 MW Bridgeport Illinois Coal	350 MW Burlington Wyoming Coal Illinois Coal	350 MW Burlington Wyoming Coal Wyoming Coal	350 MW Burlington Illinois Coal Illinois Coal	600 MW Burlington Wyoming Coal Illinois Coal	600 MW Burlington Wyoming Coal Wyoming Coal	600 MW Burlington Illinois Coal Illinois Coal	600 MW Sites F & G Wyoming Coal	600 MW Sites F & G Illinois Coal
Siting Considerations										
Land Acquisition	Substation + Ash Ponds - Approx. 250 Acres	Substation + Ash Ponds - Approx. 250 Acres	Ash Pond - 200 Acres	Ash Pond - 200 Acres	Ash Pond - 200 Acres	Ash Pond - 200 Acres	Ash Pond - 200 Acres	Ash Pond - 200 Acres	600 Acres	600 Acres
Site Accessibilities Rail	3-1/2 mile Spur	3-1/2 mile Spur	On Site - Extensions	On Site - Extensions	On Site - Extensions	Extend for Unit Train	Extend for Unit Train	Enlarge for Unit Train	-- Minimum Spur	-- Minimum Spur
Highway	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Site Versatility	Poor	Poor	Fair	Fair	Fair	Fair	Fair	Fair	Good	Good
Substation Requirements	161 kV	161 kV	345 kV	345 kV	345 kV	345 kV	345 kV	345 kV	345 kV	345 kV
Emission Control (New Unit) Particulate	Hot Gas ESP	Hot Gas ESP	Hot Gas ESP	Hot Gas ESP	Cold Gas ESP	Hot Gas ESP	Hot Gas ESP	Cold Gas ESP	Hot Gas ESP	Cold Gas ESP
SO_2	--	Scrubber	--	--	Scrubber	--	--	Scrubber	--	Scrubber
Emission Control (Existing Unit) Particulate	--	--	--	Gas Conditioning	--	--	Gas Conditioning	--	--	--
SO_2	--	--	Scrubber	--	Scrubber	Scrubber	--	Scrubber	--	--
Coal Handling	New System	New System	New System	Extend Existing	Extend Existing	New System	Extend Existing or New System	Extend Existing or New System	New System	New System
Circulating Water	C. Towers	C. Towers	C. Towers or possibly once-through	C. Towers or possibly once-through	C. Towers or possibly once-through	C. Towers	C. Towers	C. Towers	C. Towers	C. Towers
Estimated Cost of Equipment, Materials, and Construction, $/kW	306	366	344	300	397	302	280	362	281	341
Population Centers within 5 mile radius	3	3	8	8	8	8	8	8	6*	6*
Archaeological, Historical, or Cultural Landmarks	0	0	0	0	0	0	0	0	0	0

Table 6-2*

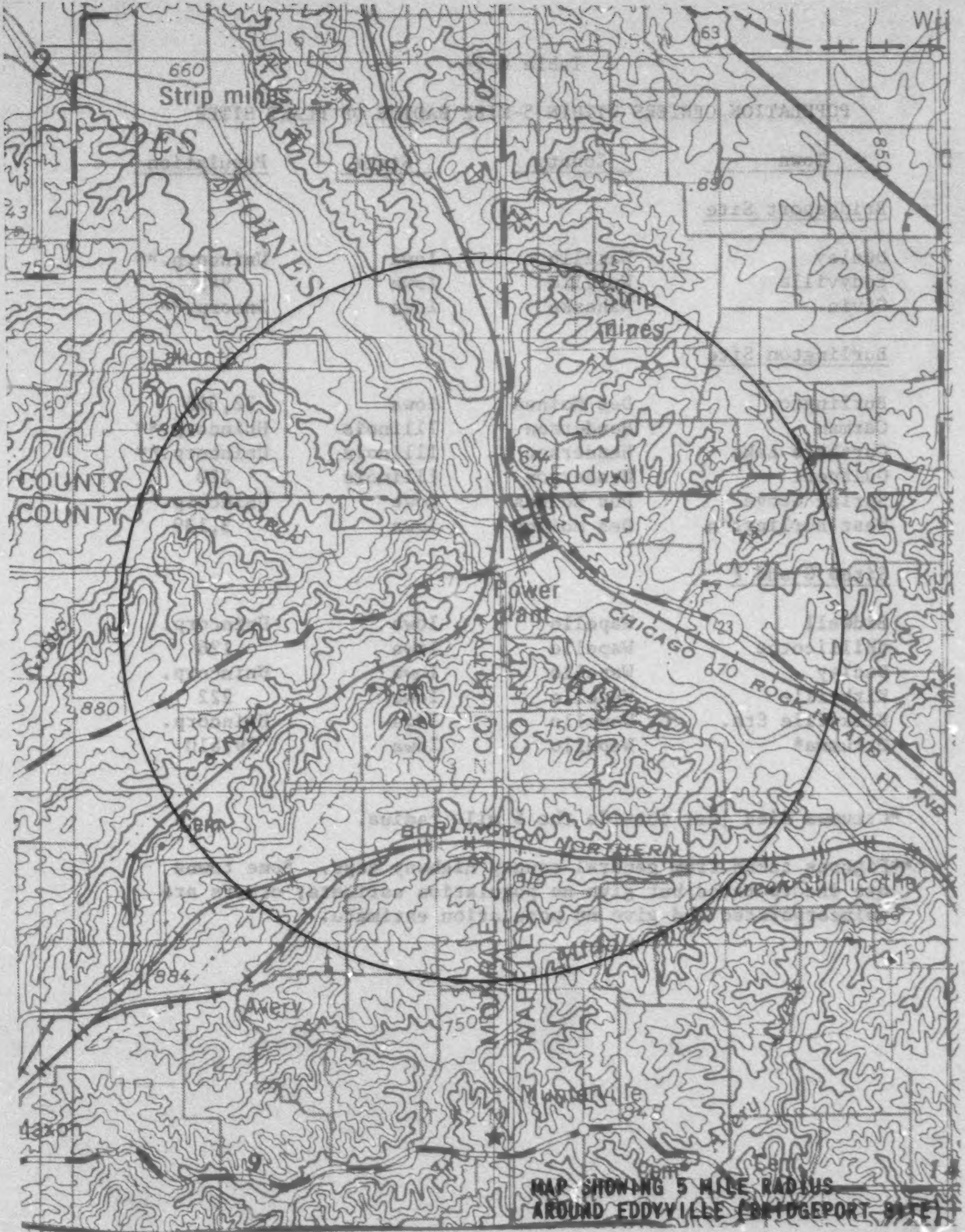
POPULATION CENTERS WITHIN 5-MILE RADIUS OF PLANT SITES

Town	County	State	Population
Bridgeport Site			
Dudley	Wapello	Iowa	Unincorp.**
Eddyville	Wapello	Iowa	945
Givin	Mahaska	Iowa	Incorp.**
Burlington Site			
Burlington	Des Moines	Iowa	32,366
Carman	Henderson	Illinois	Unincorp.**
Carthage Lake	Henderson	Illinois	Unincorp.**
Gulfport	Henderson	Illinois	220
Spring Grove	Des Moines	Iowa	Unincorp.**
West Burlington	Des Moines	Iowa	3,139
Sites G and F			
Bidwell	Wapello	Iowa	Unincorp.
Chillicothe	Wapello	Iowa	126
Dudley	Wapello	Iowa	Unincorp.
Kirkville	Wapello	Iowa	222
Kirkville Sta.	Wapello	Iowa	Unincorp.
Ottumwa*	Wapello	Iowa	29,610

*Ottumwa lies just outside the 5 mile radius.

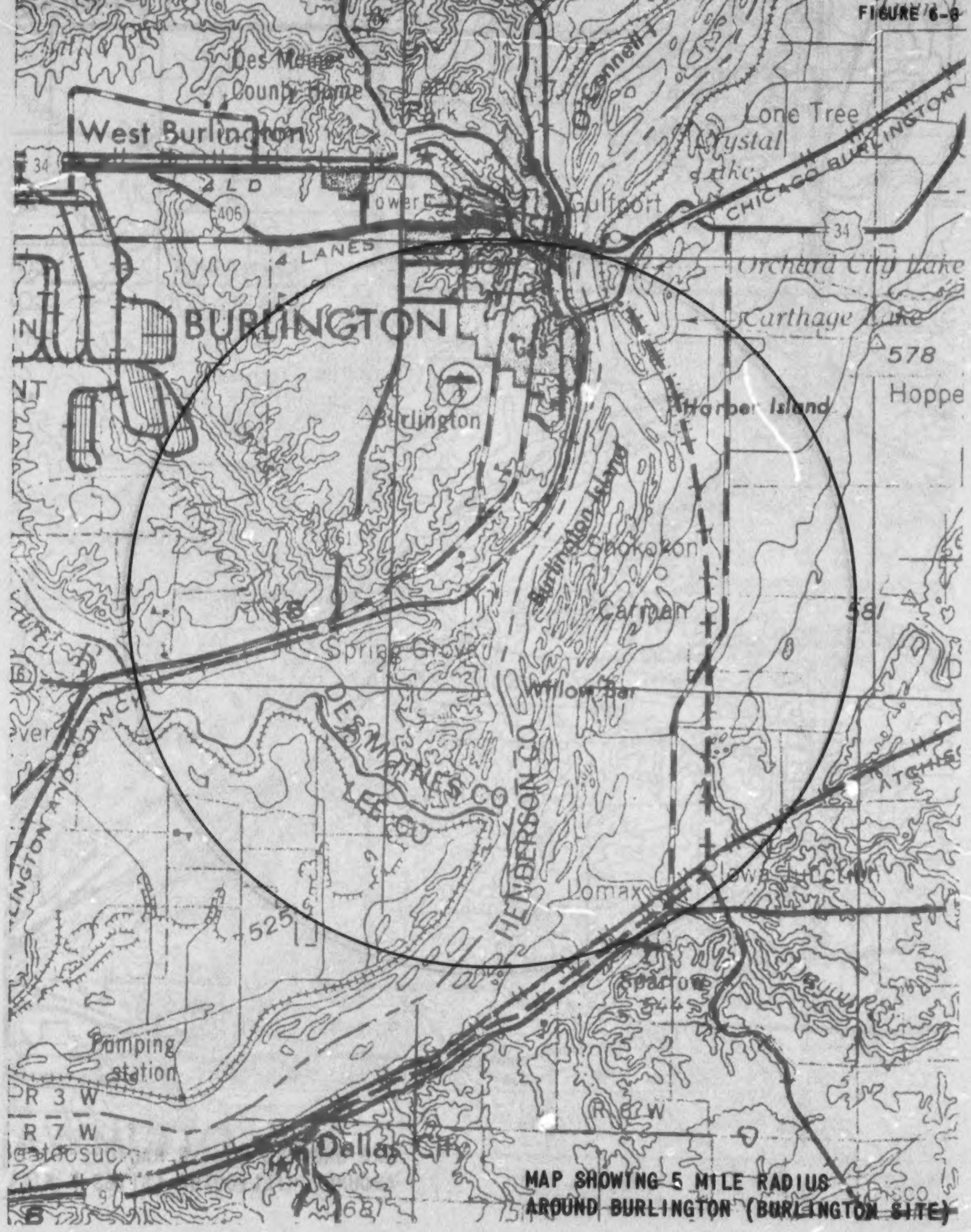
**Figures taken from general county highway maps. Some towns are incorporated but give no population estimate; others are unincorporated and give no population estimate.

FIGURE 6-2



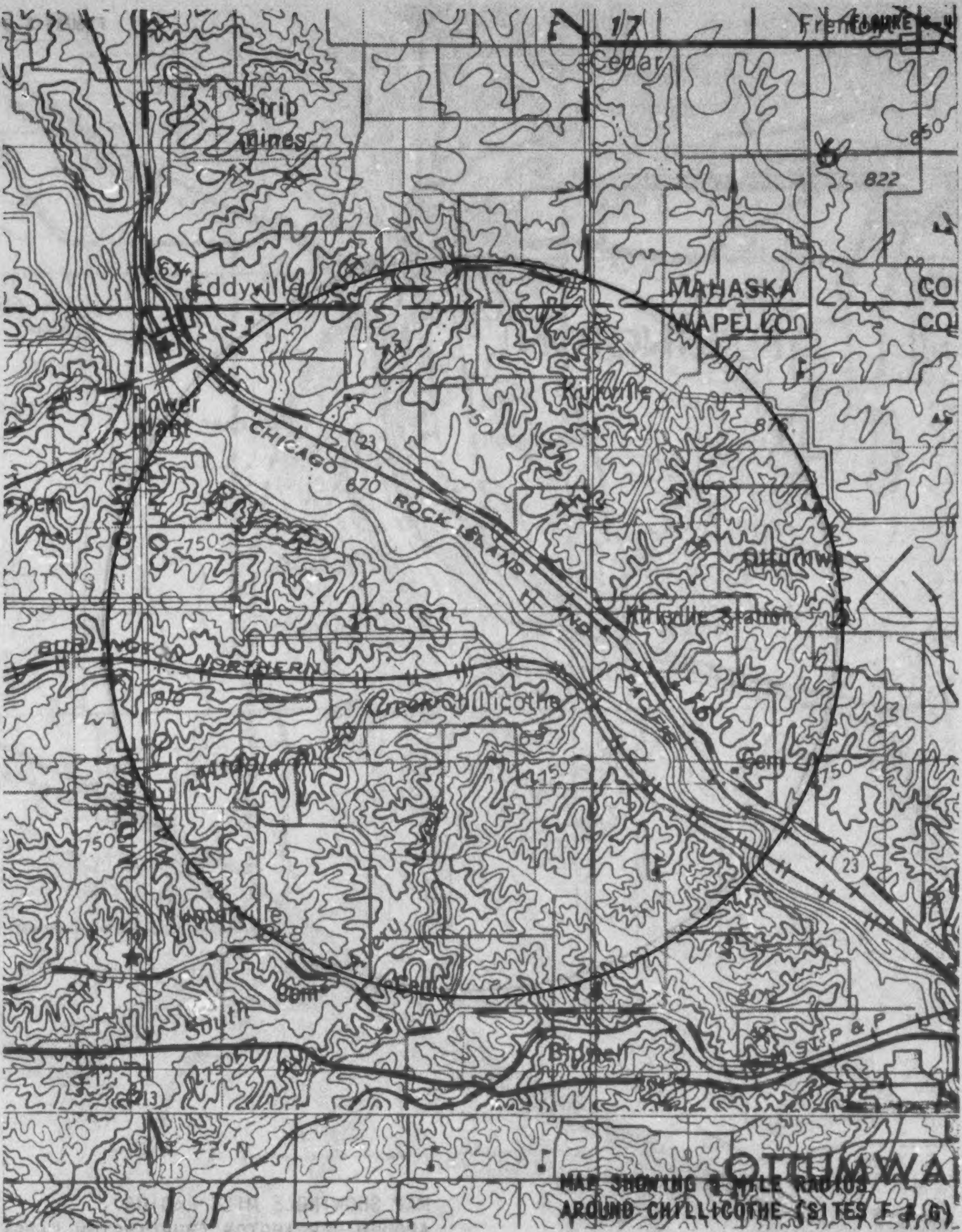
MAP SHOWING 5 MILE RADIUS AROUND EDDYVILLE (BRIDGEPORT SITE)

FIGURE 6-8



MAP SHOWING 5 MILE RADIUS AROUND BURLINGTON (BURLINGTON SITE)

FIGURE 6.4



MAP SHOWING 8 MILE RADIUS
AROUND CHILLICOTHE (SITES F & G)

the former Site F with the exclusion of the tract of land just north of the river.

6.0752 A 727 MW unit will be constructed instead of the proposed 350 MW and 600 MW units because it will be more efficient and economical to operate. The site is suitable for accommodating a unit of this size.

6.0753 Service area. The site is located in the Iowa Southern Utilities' service area.

6.0754 Land area and use. The plant site will consist of approximately 795 acres. The majority of the land on the site and surrounding areas is currently used for agricultural purposes. The site will be converted from agricultural to commercial use.

6.0755 Water supply. Water needed for station makeup will be obtained from the Des Moines River.

6.0756 Transportation access. The site chosen is located on a main line of the Burlington-Northern Railroad, which gives it direct access to western coal mines.

6.0757 There is access to three county maintained roads (21, 27, and 67) within the 5-mile radius of Chillicothe; State Highway 23, on the north side of the river, runs southeast from Eddyville to Ottumwa, with a link at Kirksville Station to Chillicothe.

6.0758 Population. The selected site is located in a low density population area.

6.0759 Air navigation interference. Since the height of the stack will be over 200 feet, a determination as to the possible hazard to air navigation will be needed from the FAA. No interference to air navigation is anticipated.

6.07510 Electric load. The generating station will be centrally located with respect to the load, and therefore, the transmission costs will be minimal.

6.07511 Environmentally sensitive areas. The proposed plant site is not near any park, animal refuge, wetlands, or historical site.

6.07512 Emissions. The emissions from the facility will not have an offensive odor and, due to the low concentrations, will not be dangerous. Low sulfur coal will be used as fuel and all emission standards will be met.

6.07513 Final selection. The location selected was the most suitable of the potential sites considered. Deciding factors included the easy transportation access to coal supply; the abundant water supply due to the site's location on the Des Moines River; and the central location of the site in relation to the load and the minimal transmission costs.

6.08 Transmission System Selection

6.081 Introduction. Starting in August 1975, Ottumwa Generating Station owners have been studying the transmission system which will be required to transmit OGS generation to the loads. The study so far has dealt primarily with system operation and reliability aspects. Two different transmission systems are being considered. Before a final decision is made, both of these systems must be completely evaluated from the following standpoints.

6.0811 System reliability and operation

6.0812 System stability

6.0813 Economics

6.0814 Coordination with future requirements

6.082 Transmission Routing. After the proper transmission system has been selected, alternate routes for each new line in the system will be considered. Environmental compatibility and the economics of construction and operation will be major considerations in the selection of routes.

6.0821 Specific guidelines which will be followed in route selection are:

6.08211 Transmission line rights-of-way will avoid cemeteries, quarries, airports and air landing strip facilities, monuments, parks, recreational areas, environmentally sensitive areas, historic sites, houses, and buildings.

6.08212 Construction methods will be employed that minimize disturbances to roads, land, and improvements. During construction, rights-of-way will be maintained to avoid litter problems. Where temporary roads are required, the area will be graded to minimize soil erosion. Creek and small stream crossings will be constructed to avoid restricting the flow of water. Construction of rights-of-way will not affect ponds and shoreline wildlife habitat. Wherever possible, existing roads will be used and maintained during construction.

6.08213 After the construction of transmission lines, ground cover vegetation and small trees will be allowed to grow on the rights-of-way. Crops and pasture land use under transmission lines can be carried on with no disturbance.

6.08214 Special efforts will be made to route lines along and parallel to the slope of hills, rather than ridge line construction, to minimize line visibility.

6.08215 Transmission lines will be designed to eliminate radio and television interference. Conductor sizes, configurations, fittings, and insulators will be designed to avoid such interference.

6.08216 Periodic inspection of the transmission facilities will be made and proper maintenance of the line and rights-of-way carried out.

6.08217 Developed areas and areas of potential development will be avoided.

6.08218 Where possible, the right-of-way will be confined to areas devoted to timber and pasture land use. Intensively cultivated areas will be avoided. Wherever possible, structures will be located in fences or in wasteland.

6.08219 Densely populated areas will be avoided.

6.083 Alternate Transmission Systems. The two transmission systems being considered are a system composed of five 161 kV lines, and a system composed of one 345 kV and three 161 kV lines.

6.0831 Alternate 1--161 kV system. The all 161 kV system will consist of five 161 kV lines. The terminals of the lines are listed below and possible routing is shown on Figure 6-5.

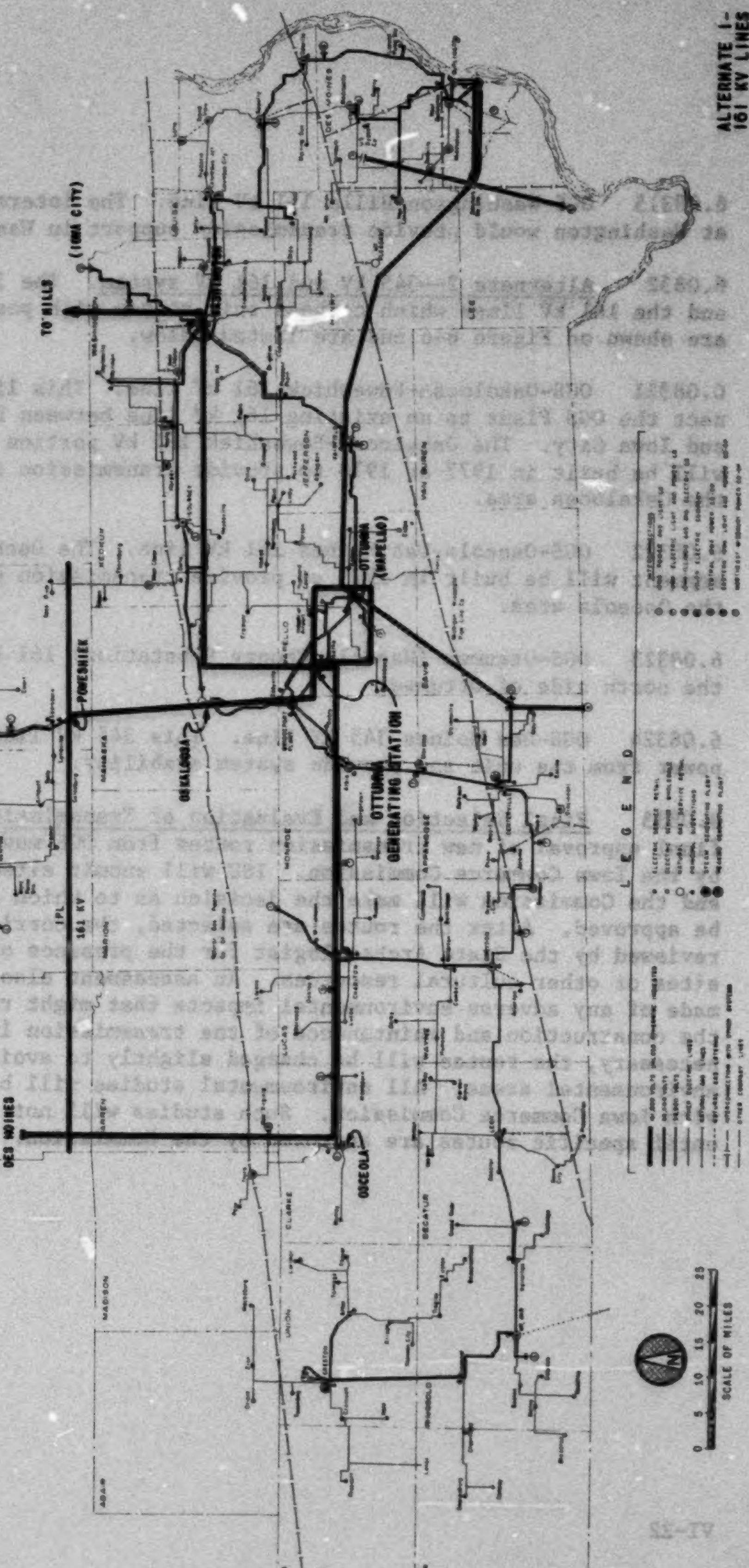
6.08311 OGS-Oskaloosa-Poweshiek 161 kV line. This line will connect the OGS Plant to an existing 161 kV line between Des Moines and Iowa City. The Oskaloosa-Poweshiek 161 kV portion of this line will be built in 1977 or 1978 to provide transmission support to the Oskaloosa area.

6.08312 OGS-Osceola-Des Moines 161 kV line. The Osceola-Des Moines segment will be built in 1979 to provide transmission support to the Osceola area.

6.08313 OGS-Ottumwa (Wapello County Substation) 161 kV line around the north side of Ottumwa.

6.08314 OGS-Ottumwa (Wapello County Substation) 161 kV line around the south side of Ottumwa. Two 161 kV lines from OGS to Ottumwa are required because of the heavy power flows in this segment and to provide unit stability.

FIGURE 6-5


ALTERNATE I-
161 KV LINES
DES MOINES
IPL 161 KV
POWESHIEK
OSKALOOSA
OTTUMWA GENERATING STATION
OTTUMWA (WAPELLO)
OSCEOLA
TO HILLS (IOWA CITY)
JEFFERSON
KEOKUK
MAHASKA
MARION
WARREN
POLK
JASPER
CLARKE
LUCAS
MONROE
DECATUR
WAYNE
APPANOOSE
DAVIS
VAN BUREN
LEE
DES MOINES
UNION
MADISON
ADAIR
ADAMS
TAYLOR
RINGGOLD
LEGEND
SCALE OF MILES
0 5 10 15 20 25

6.08315 OGS-Washington-Hills 161 kV line. The intermediate terminal at Washington would provide transmission support in Washington.

6.0832 Alternate 2--345 kV and 161 kV system. The 345 kV lines and the 161 kV lines which compose this system with possible routing are shown on Figure 6-6 and are listed below.

6.08321 OGS-Oskaloosa-Poweshiek 161 kV line. This line will connect the OGS Plant to an existing 161 kV line between Des Moines and Iowa City. The Oskaloosa-Poweshiek 161 kV portion of this line will be built in 1977 or 1978 to provide transmission support to the Oskaloosa area.

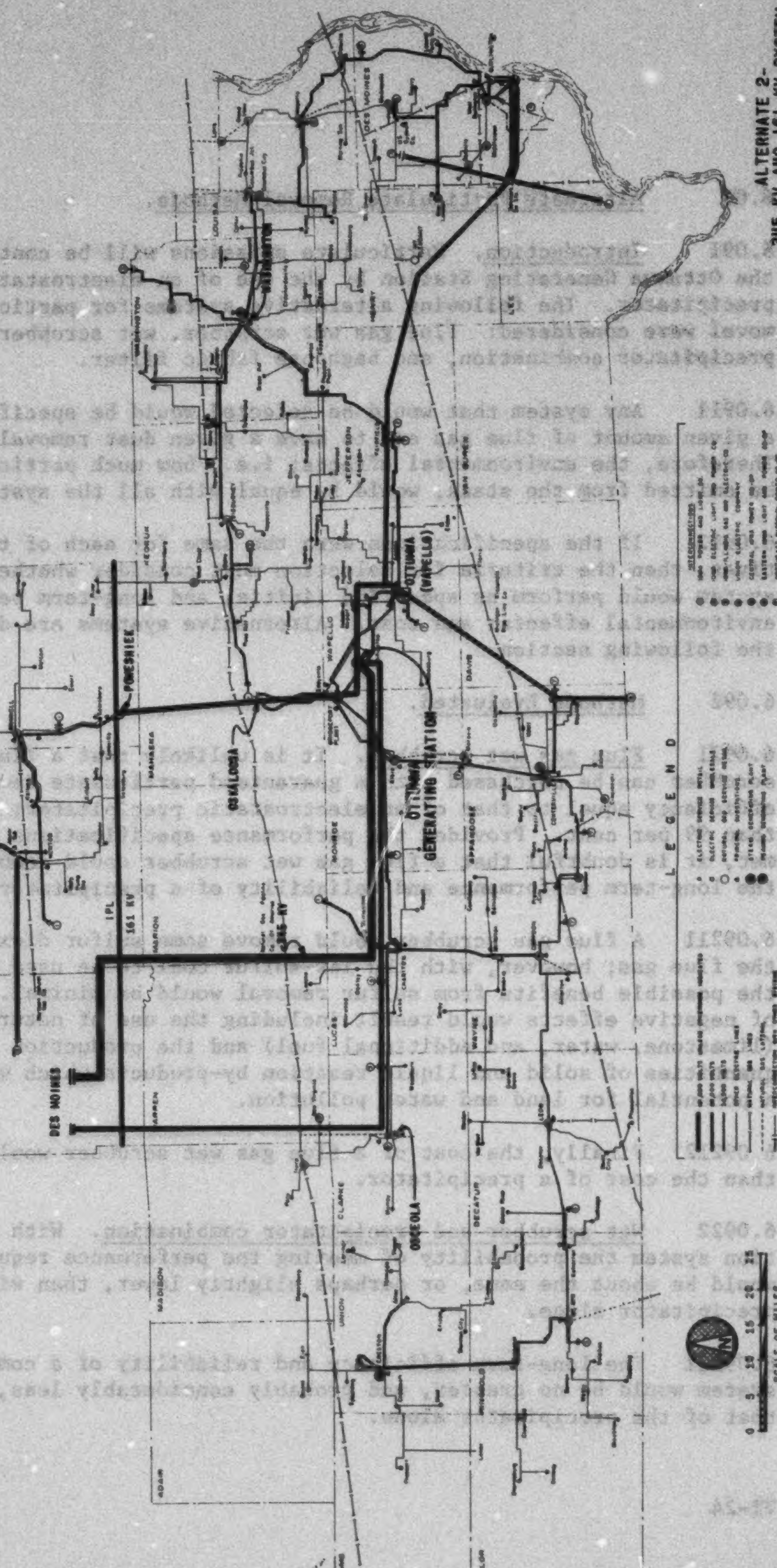
6.08322 OGS-Osceola-Des Moines 161 kV line. The Osceola-Des Moines segment will be built in 1979 to provide transmission support to the Osceola area.

6.08323 OGS-Ottumwa (Wapello County Substation) 161 kV line around the north side of Ottumwa.

6.08324 OGS-Des Moines 345 kV line. This 345 kV line will transmit power from the unit and provide system stability.

6.0833 Final Selection and Evaluation of Transmission Routes. The final approval of new transmission routes from OGS must be made by the Iowa Commerce Commission. ISU will submit alternate plans and the Commission will make the decision as to which routes will be approved. After the routes are selected, the corridors will be reviewed by the State Archaeologist for the presence of archaeological sites or other cultural resources. An assessment also will be made of any adverse environmental impacts that might result from the construction and maintenance of the transmission lines. If necessary, the routes will be changed slightly to avoid any sensitive environmental areas. All environmental studies will be coordinated with Iowa Commerce Commission. Such studies will not be initiated until specific routes are approved by the Commission.

FIGURE 6-6



ALTERNATE 2-
345 KV AND 161 KV SYSTEM

6.09 Alternate Particulate Removal Methods.

6.091 Introduction. Particulate emissions will be controlled at the Ottumwa Generating Station by the use of an electrostatic precipitator. The following alternative systems for particulate removal were considered: flue gas wet scrubber, wet scrubber and precipitator combination, and baghouse fabric filter.

6.0911 Any system that would be selected would be specified to treat a given amount of flue gas and to have a given dust removal efficiency. Therefore, the environmental effects; i.e., how much particulate would be emitted from the stack, would be equal with all the systems.

6.0912 If the specifications were the same for each of the alternatives, then the criteria for selection must consider whether the system would perform as specified (initial and long-term performance); environmental effects; and cost. Alternative systems are discussed in the following section.

6.092 Methods Evaluated.

6.0921 Flue gas wet scrubber. It is unlikely that a flue gas wet scrubber can be purchased with a guaranteed particulate removal efficiency equal to that of an electrostatic precipitator; i.e., greater than 99 per cent. Provided the performance specifications could be met, it is doubtful that a flue gas wet scrubber could demonstrate the long-term performance and reliability of a precipitator.

6.09211 A flue gas scrubber would remove some sulfur dioxide from the flue gas; however, with the low-sulfur coal to be used for fuel, the possible benefits from sulfur removal would be minimal. A number of negative effects would result including the use of natural resources (limestone, water, and additional fuel) and the production of large quantities of solid and liquid reaction by-products which would present a potential for land and water pollution.

6.09212 Finally, the cost of a flue gas wet scrubber would be higher than the cost of a precipitator.

6.0922 Wet scrubber and precipitator combination. With a combination system the probability of meeting the performance requirements would be about the same, or perhaps slightly lower, than with the precipitator alone.

6.09221 The long-term efficiency and reliability of a combination system would be no greater, and probably considerably less, than that of the precipitator alone.

6.09222 Secondary environmental effects for the combination system would be the same as for the scrubber alone, except for still higher fuel usage (to generate the power required to operate both systems).

6.09223 The cost of a combination system would be about 10 to 20 million dollars more than the cost of a precipitator.

6.0923 Baghouse fabric filter. A well-designed fabric filter would have the greatest probability of meeting the performance requirements than the other systems considered.

6.09231 The use of fabric filters in central station coal-fired utilities is a relatively recent application. Operating experience, reliability, and maintenance cost have not been established.

6.09232 Environmental effects would be about the same for either a fabric filter or precipitator.

6.09233 The initial costs would be approximately the same for either system.

6.10 Alternate Sulfur Dioxide (SO_2) Removal Methods.

6.101 The western coal to be used for fuel at Ottumwa Generating Station has a sulfur content of about 0.5 per cent. Because of the low sulfur content, sulfur dioxide emission will comply with regulatory requirements and no removal treatment is contemplated. The generating station has been designed to accommodate sulfur dioxide removal equipment should a coal with higher sulfur content be used for fuel in the future or if regulatory requirements should change.

6.11 Alternative Ash Disposal Methods.

6.111 The following methods of ash disposal were considered for the Ottumwa Generating Station.

6.1111 Local Off-Site Disposal. The development of an off-site disposal area for bottom ash and dry ash would result in higher operating costs. In addition to on-site disposal being less expensive, handling and disposal methods can be better controlled, and any environmental effects can be efficiently monitored.

6.1112 Shipment of Ash Back to the Mine. It would be possible that the ash could be shipped back to the western coal mine in coal railcars. The costs of preparing the ash for shipment and for transportation are considered prohibitive. There also would be a sizable expenditure of energy in returning the ash to the mine site.

6.1113 Marketing of Fly Ash. There is a limited market potential for fly ash. Fly ash has been used in the manufacture of cement and as an additive for concrete. If a suitable commercial outlet could be developed, the fly ash from the Ottumwa Plant could be sold. Facilities would have to be provided for storage and loading of fly ash into trucks or train cars for shipment to market. Based on present demand, considerably more fly ash would be produced than could be sold.

6.12 Alternate Cooling Methods

6.121 Introduction. There are several alternative cooling systems available for power plants. Basically, each alternate process represents a different method for the disposal of the unrecoverable energy in the exhaust steam discharged from the steam turbine.

6.1211 Fossil fuel (or nuclear fuel) is used to provide energy to generate steam which then is expanded through steam turbines where a portion of the heat energy of the steam is converted to mechanical energy to drive an electrical generator. Much of the heat energy in the steam is thermodynamically unavailable to produce mechanical-electrical energy, and it must be discharged.

6.1212 The transfer of unavailable heat (i.e. waste heat) in the exhaust steam is carried out in a sequence of three general steps. The heat is first transferred to an intermediate heat-transport fluid (circulating water); secondly, the heat is transferred by the cooling system to the atmosphere; and, finally, the heat is passed to the ultimate heat sink which is outer space.

6.1213 A condenser is commonly used to transfer unavailable heat energy discharged from the steam turbine. There is a shell housing tubes through which circulating water flows. Steam condenses on the outside of the tube surfaces as the heat transfers to the circulating water. The circulating water transports the heat to some type of cooling facility where it is dissipated ultimately to space.

6.1214 Cooling systems differ in the manner in which the final transfer of waste heat from the circulating water to the environment is accomplished. There may be a direct transfer of heat from the water to the atmosphere, or the circulating water may be discharged into and mixed with a large body of water where the waste heat transfers to the atmosphere.

6.1215 With all the processes, heat is transferred from the circulating water to the atmosphere by the following mechanisms.

6.12151 Conduction and convection of heat directly to the air.

6.12152 Radiation of heat from the higher temperature water surfaces to the lower temperature of the atmosphere.

6.12153 The evaporation of a portion of the circulating water (or receiving water) with the transfer of heat from water to water vapor which is diffused into the atmosphere.

6.1216 Whether waste heat is transferred directly to the atmosphere or it is eventually transferred from large bodies of water, the same fundamental mechanisms of heat transfer apply. The amount of waste heat transferred by the mechanisms listed varies with the different cooling systems. The total heat transferred, however, is equal to the waste heat discharged to the circulating water through the steam condenser. (It should be noted that although it is possible to directly transfer from exhaust steam to the atmosphere through a heat exchanger, this method is applicable only on a limited basis).

6.122 Types of Cooling Systems. Alternate cooling systems that are considered feasible for large electric-generating units include the following.

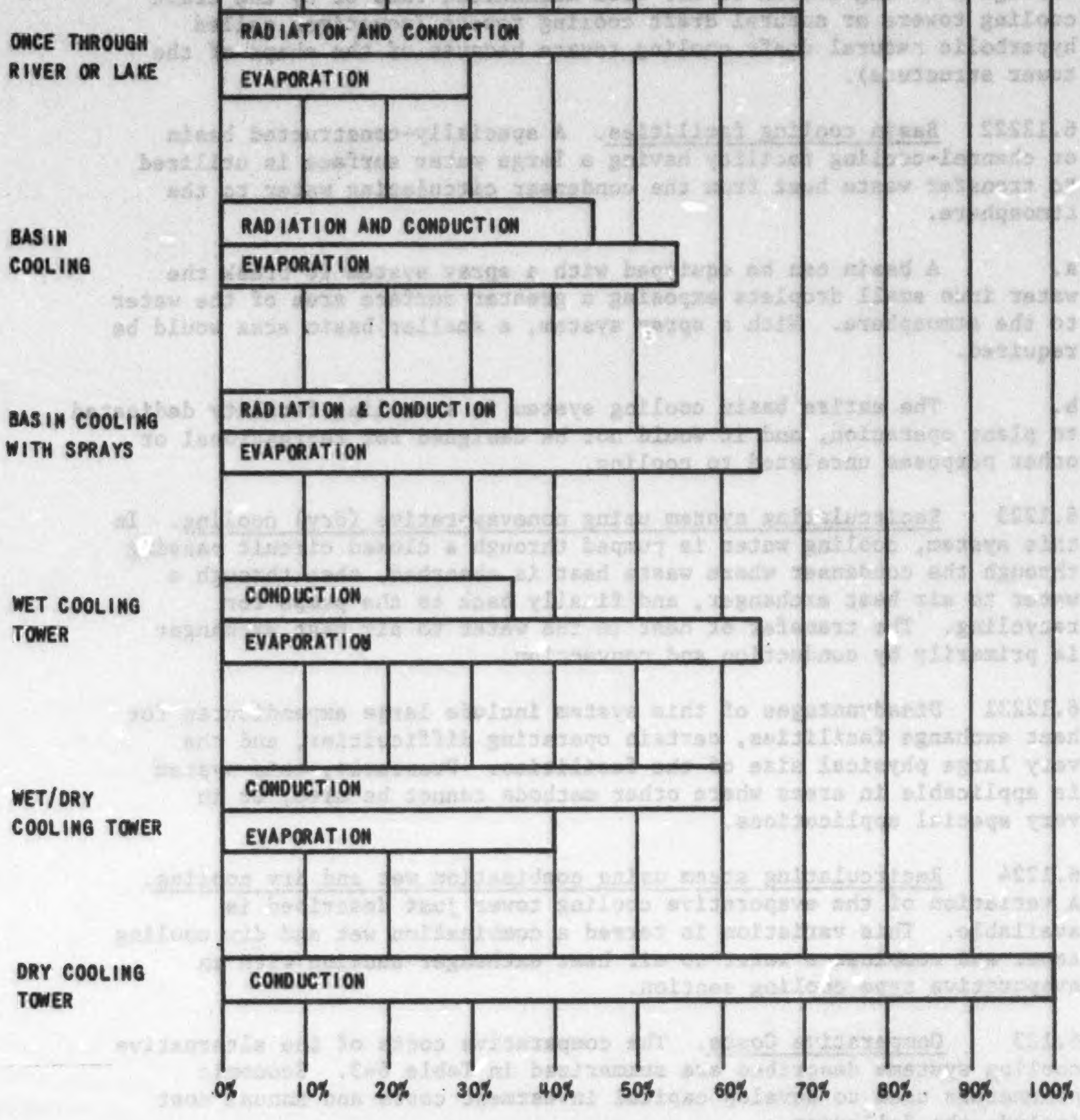
- Once-through cooling system
- Recirculating system using evaporative (wet) cooling
- Recirculating system using nonevaporative (dry) cooling
- Recirculating system using combination wet and dry cooling

6.1221 Once-through cooling system. This process uses river or lake water circulating in a continuous circuit through the tubes of a condenser, absorbing the waste heat, and then returning to the water body. The transfer of heat to the atmosphere then occurs because of the temperature difference between the water and the atmosphere.

6.12211 Features of once-through systems include an intake structure, circulating water pumps to provide static and dynamic head losses, the condenser, conduits to carry water, and a discharge structure located so that significant recirculation of warm water will not occur. This type of cooling system has been utilized where natural bodies of water of adequate quantity are available. Once-through cooling is not practical for Ottumwa Station because there is not an adequate supply of water available from the Des Moines River during periods of low flow.

6.1222 Recirculating system using evaporative (wet) cooling. In this system, heat is transferred directly from the circulating water surfaces to the atmosphere employing equipment and structures specifically designed and constructed as a part of the plant. Heat transfer is a result of a combination of evaporation and conduction with some radiation. There are several forms of this system that differ in technical details, costs, and operating problems. The following types of such cooling systems are available.

FIGURE 6-7



HEAT TRANSFER MECHANISMS
WITH ALTERNATIVE COOLING SYSTEMS

SOURCE: WOODSON, R.D., NOVEMBER 30, 1972.

6.12221 Cooling tower system. Circulating water is elevated and broken up within the cooling tower and then it is dropped to a basin through a moving column of air from mechanical fans or by the draft cooling towers or natural draft cooling towers (sometimes called hyperbolic natural draft cooling towers because of the shape of the tower structure).

6.12222 Basin cooling facilities. A specially-constructed basin or channel-cooling facility having a large water surface is utilized to transfer waste heat from the condenser circulating water to the atmosphere.

a. A basin can be equipped with a spray system to break the water into small droplets exposing a greater surface area of the water to the atmosphere. With a spray system, a smaller basin area would be required.

b. The entire basin cooling system is a cooling facility dedicated to plant operation, and it would not be designed for recreational or other purposes unrelated to cooling.

6.1223 Recirculating system using nonevaporative (dry) cooling. In this system, cooling water is pumped through a closed circuit passing through the condenser where waste heat is absorbed, then through a water to air heat exchanger, and finally back to the pumps for recycling. The transfer of heat in the water to air heat exchanger is primarily by conduction and convection.

6.12231 Disadvantages of this system include large expenditures for heat exchange facilities, certain operating difficulties, and the very large physical size of the facilities. Presently, this system is applicable in areas where other methods cannot be used, or in very special applications.

6.1224 Recirculating steam using combination wet and dry cooling. A variation of the evaporative cooling tower just described is available. This variation is termed a combination wet and dry cooling tower and combines a water to air heat exchanger section with an evaporative type cooling section.

6.123 Comparative Costs. The comparative costs of the alternative cooling systems described are summarized in Table 6-3. Economic parameters used to develop capital investment costs and annual cost include the following.

- Annual fixed charges of 15.92 per cent

TABLE 6-3

COMPARATIVE COSTS OF ALTERNATE COOLING SYSTEMS

FOSSIL FUEL PLANT WITH
675 MW NET PLANT OUTPUT

Type of Cooling System*	Capital Investment $	Annual Fixed Charges $	Annual Operation and Maintenance $	Total Annual $	Capital Equivalent of Total Annual Costs $
Mechanical Draft Wet Tower	10,300,000	1,640,000	667,000	2,307,000	14,491,000
Natural Draft Wet Tower	14,400,000	2,292,000	566,000	2,858,000	17,952,000
Mechanical Draft Dry Tower	24,900,000	3,964,000	4,790,000	8,754,000	54,987,000
Mechanical Draft Wet/Dry Tower	12,600,000	2,006,000	712,000	2,718,000	17,073,000

*Once-through cooling is not practical for OGS because of limited water supply available from Des Moines River. Basin cooling is not feasible because of the topography of the plant site area.

- Inclusion in capital cost of 20.75 per cent as general indirect investment costs
- Plant capacity factor--55.8 per cent
- Cost in 1975 dollars
- Cost of electric power requirements at $26.59 per kW per year
- Cost of electric energy consumption at 11 mills per kWh

6.1231 Mechanical draft wet towers are the most economical cooling system of those practical for the Ottumwa Generating Station.

6.124 Comparative Utilization of Natural Resources. Table 6-4 shows the comparative utilization of important natural resources for each of the alternate cooling systems. (Water use at 100 per cent load capacity for draft cooling towers is shown in Table 1-4.)

6.125 Qualitative Ranking of Cooling System Characteristics. Table 6-5 shows the comparative qualitative ranking of each alternative for a number of individual cooling system characteristics. The sum of the qualitative rankings for each system represents an approximation of the quantitative ranking of the alternative systems.

6.1251 As shown in Table 6-5 draft cooling towers ranks as one of the more desirable systems.

6.126 Selection of Cooling System for Ottumwa Station. Draft cooling towers were selected for use at Ottumwa Station primarily on the basis of environmental considerations, economics, utilization of natural resources, and desirable characteristics. Water from the Des Moines River will be recycled for plant use as much as possible, and there will be no thermal impacts as a result of wastewater discharges. Blowdown from the cooling towers will be used for bottom ash sluicing and finally discharged to the bottom ash basin prior to discharge to the river.

TABLE 6-4

COMPARATIVE UTILIZATION OF NATURAL RESOURCES WITH ALTERNATIVE COOLING SYSTEMS FOR FOSSIL FUEL PLANT WITH 675 MW NET PLANT OUTPUT

(55.8 per cent annual load factor)

Type of Cooling System	Net Generating Capacity kilowatts	Net Plant Heat Rate Btu/kWh	Fuel Input Billions of Btu/yr	Coal Consumption 8020 Btu/lb tons/yr	Water Consumption (Evaporation) acre-ft/yr	Land Area acres
BASE REQUIREMENTS						
Once-through River or Lake Cooling System[a]	675,000	10,000	32,995	2,057,000	2,650	—
ADDITIONS TO BASE REQUIREMENTS						
	Aux Power kilowatts					
Alternative Cooling Systems						
Mechanical draft wet tower	4,390	77	254	15,800	6,300	15
Mechanical draft wet/dry tower	5,430	86	284	17,700	2,800	15
Mechanical draft dry tower	17,600	1,123	3,705	231,000	(2,800)[b]	6
Natural draft wet tower	3,040	59	195	12,200	6,300	15

[a] Not practical for the Ottumwa Generating Station.

[b] Denotes decreased requirements.

TABLE 6-5

QUALITATIVE RANKING OF COOLING SYSTEM CHARACTERISTICS

	Once-through Cooling	Dry Cooling Towers	Wet-Dry Cooling Towers	Mechanical Draft Cooling Towers	Natural Draft (Hyperbolic) Cooling Towers
1. Comparative Cost	1	5	3	2	3
2. Ability to Satisfy Cooling Requirements	1	2	2	1	1
3. Availability	1	4	3	1	1
4. Low Temperature Adaptability	2	5	5	3	4
5. Fire Risk	1	1	3	3	2
6. Windstorm Risk	1	2	3	2	5
7. Seismic Risk	2	2	2	1	5
8. Ability to Tolerate Airborne Debris	2	3	2	1	1
9. Corrosion Resistance	2	3	3	1	1
10. Maintenance Requirements	2	5	3	2	2
11. Land Requirements	1	3	2	2	2
12. Arrangement of Plant Facilities	2	4	1	2	1
13. Arrangement of Site	5	1	1	1	1
14. Impact on Water Resources	2	1	2	4	4
15. Atmospheric Concerns	1	1	2	3	3
16. Extent of Field Construction	3	3	2	1	4
Approximation of the Quantitative Ranking of Alternate Cooling Systems*	29	45	39	30	40

Ratings are qualitative only and are ranked from 1 to 5 in order of desirability with respect to each characteristic, with 1 being the most desirable and 5 being the least desirable.

*Sum of qualitative rankings.

BIBLIOGRAPHY

Woodson, R.D., November 1972, Cooling Alternatives for Power Plants, Presented to the Minnesota Pollution Control Agency.

6.13 Alternatives Available to Reduce Demand

6.131 Advertising and Conservation Information Programs. Until recently, utilities have conducted advertising campaigns to increase the demand for electric power in their service areas. Promotional advertising has been discontinued and information is now being provided concerning energy conservation measures; e.g. better insulation, low temperatures in the winter, high temperatures in the summer, etc. In some instances, the use of electric space heating is being encouraged as a replacement for heating using fuels in short supply such as oil, natural gas, and propane.

6.1311 Iowa Southern Utilities Company and the other utility companies in Iowa have sponsored a variety of advertising and have participated in programs directed toward the conservation of electric energy by their customers. As an illustration, Table 6-6 lists energy conservation advertisements sponsored by ISU during 1975 and 1976.

6.1312 During 1976, Iowa utility companies also participated in the Iowa Community Betterment Programs administered by the Iowa Development Commission. The program had as its objectives the stimulation of greater interest, concern, and involvement for the improvement of the physical, environmental, social, cultural, and economic aspects of Iowa communities and their surrounding areas. Six Iowa communities undertook energy conservation projects, and Akron, Iowa was awarded the Commission's "Youth Involvement Award."(1) Their weatherization project involved the insulation of homes and roof repair.

6.132 Adjustment of Rate Schedules. It has been suggested that utilities increase their electric rates in such a manner as to encourage a reduction in use. In the past, utility rate structures have been designed to promote consumption of electricity by using the declining block rates. These rates reflect the declining average cost of furnishing additional killowatt hours of electrical energy to each customer. Only since attention has been focused on energy conservation have declining block rates been questioned.

6.1321 To discourage the use of electricity, possible actions include increasing block rates, peak load pricing, and flat rates. It is not known at what point consumers would significantly curtail their use of electricity rather than pay an increased price. Several state and federal government studies are being conducted to make such a determination.

6.1322 During August 1976, ISU advertisements advised customers that electricity consumers who used more than 800 kilowatt hours in a month during June, July, August, and September would be charged

Table 6-6

ENERGY CONSERVATION ADVERTISEMENTS SPONSORED BY
IOWA SOUTHERN UTILITIES COMPANY DURING 1975-1976

Title	Publication Date
Heat Energy Dollar	January 1975
A Do-It-Yourself Kit To Save Energy & $ $ $	April 1975
How To Insulate Your Home Yourself[a]	April 1975
Switching To Electric Heat? We Can Help![a]	May 1975
Lets Talk About Your Natural Gas Service Bill	March 1976
Lets Talk About Your Electricity Bill	March 1976
What's Your Air Conditioner's E.Q?	May 1976
Don't Be Shocked By Your Electric Bill!	August 1976
Insulation To Keep In the Warm Air You've Paid For	September 1976

[a] Bill inserts

.4¢ per kWh more than the rate for other months. It was explained that the extra charge would help offset additional costs of serving higher summer loads and would encourage energy conservation.

6.1323 Many factors other than price, however, influence the demand for electric power. The future demand will be affected by the economy, the continued growth of industry, developing technology, and the attitude of the people. All the factors interact to establish the demand for electricity.

6.133 Load Staggering to Reduce Peak Demand. Load staggering involves the changing of the operational hours of industrial or commercial firms to reduce the daily peak load demand. Serious objections might develop from both workers and customers as a result of such a program. Such an adverse impact might occur that the feasibility of load staggering would be questionable.

6.134 More Efficient Utilization of Electrical Energy. There are a number of ways that electricity can be more efficiently used. Considerable efficiency can be achieved in space conditioning by improved insulation, the use of building materials with better insulation properties, and by using equipment which transfers or stores excess heat or cold. Energy saving building techniques can result in a reduction of as much as 25 per cent in electrical energy usage. In 1971, the Federal Housing Administration established insulation standards designed to reduce average residential heating losses by one-third. The demand for air-conditioning also is reduced as the result of greater insulation.

6.1341 Reduction in lighting levels also can result in decreased electrical energy consumption. Lighting accounts for about 24 per cent of all electricity sold nationally. Better design of lighting systems and the substitution of fluorescent for incandescent lights would help save electric energy.

6.1342 The development of more efficient household appliances would help conserve energy. At the present, more efficient air conditioners, refrigerators, freezers and various small appliances are being developed and marketed. It has been estimated that an improvement in average efficiency from 6 to 10 Btu/Watt-hr of room air conditioners could reduce peak demand nationally 58,000 MW by 1980.

6.135 Effectiveness of Efforts to Reduce Demand. Since the Arab oil embargo, growth in electric consumption has been at a reduced rate in the United States and in Iowa. The embargo apparently created a "conservation ethic" throughout the nation and price, publicity, and conservation programs have contributed to its continuance.

6.1351 As shown in Table 6-7, the average rate of growth for Iowa has been about 7 per cent per year through 1973 but declined dramatically in 1974, the year of the embargo. Preliminary 1975 data show consumption growing by 6 per cent; however, final revised data indicate that consumption will grow by 4 per cent. Since both growth rate values are below the 7 per cent average rate, indications are that voluntary conservation has continued.

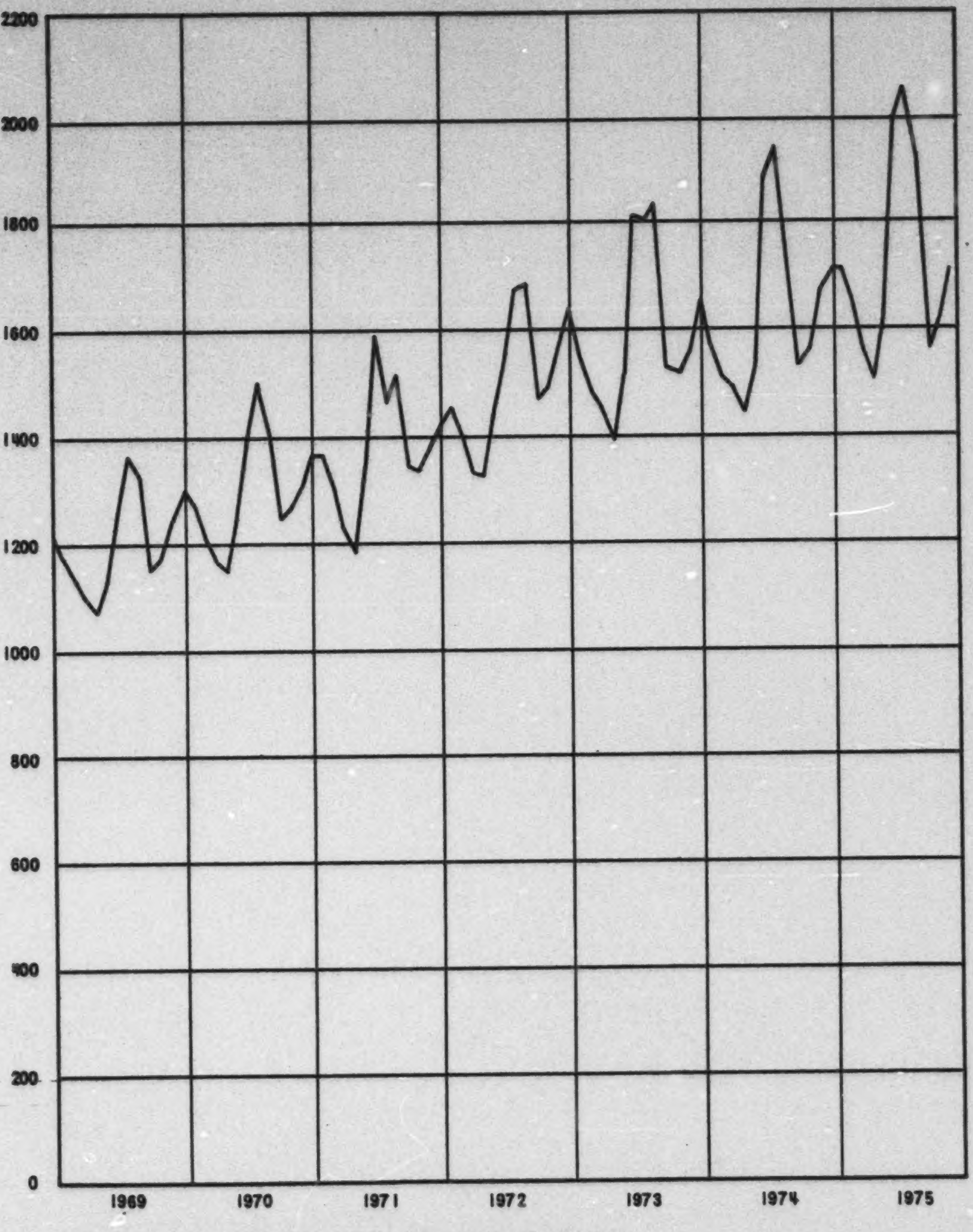
6.1352 The consumption of electric energy by ultimate consumers in Iowa is shown in Figure 6-8 for 1969 through 1975. It is apparent that peak consumption has grown at a greater rate than total consumption. Unfortunately, it is the peak demand that must be met by the utility companies. It appears that conservation results have been general in nature and there has been little or no effect in the areas of greatest need, peak demand.

Table 6-7

MONTHLY SALES OF ELECTRIC ENERGY TO ULTIMATE CONSUMERS - IOWA
(Mil. kWh)

	1969	1970	1971	1972	1973	1974	1975p	1975r	1976p	Per Cent Change 1969-1975
Jan.	1,222.3	1,295.7	1,367.1	1,418.0	1,628.0	1,649.8	1,717.0	1,703.0	1,815.8	40.47
Feb.	1,175.6	1,273.2	1,364.3	1,456.0	1,545.7	1,567.7	1,712.8	1,682.6	1,752.8	45.70
Mar.	1,136.6	1,210.8	1,309.0	1,400.0	1,481.1	1,518.0	1,655.0	1,611.1	1,671.5	45.61
Apr.	1,098.6	1,168.6	1,224.4	1,335.2	1,452.5	1,497.8	1,562.4	1,528.7	1,590.3	42.22
May	1,069.3	1,145.2	1,182.2	1,321.4	1,397.0	1,442.8	1,502.6	1,458.7	1,524.4	40.52
June	1,130.1	1,245.3	1,344.3	1,450.1	1,515.3	1,530.0	1,636.6	1,602.0	1,663.6	44.82
July	1,265.0	1,407.1	1,590.7	1,542.1	1,812.3	1,890.0	2,001.9			58.25
Aug.	1,365.2	1,500.7	1,461.6	1,679.8	1,804.4	1,942.0	2,058.9			50.81
Sept.	1,323.8	1,408.0	1,519.1	1,684.2	1,838.0	1,681.8	1,912.7			44.49
Oct.	1,151.1	1,242.7	1,343.7	1,468.4	1,528.1	1,530.6	1,555.3			35.11
Nov.	1,174.5	1,269.8	1,335.0	1,492.4	1,519.4	1,561.6	1,621.6			38.07
Dec.	1,247.5	1,304.8	1,380.2	1,563.6	1,554.1	1,674.0	1,730.7			38.73
Year	14,360.1	15,477.5	16,422.1	17,815.5	19,086.4	19,486.8	20,668.1			43.93
Change Per Cent	N/A	7.78	6.10	8.49	7.13	2.10	6.06	4.13	4.51 (6 mo.)	
Number		1,117.4	944.6	1,393.4	1,270.9	400.4	1,181.3	380.0	432.3 (6 mo.)	

p = Preliminary r=Revised
Source: Federal Power Commission, "News Release," Monthly



SOURCE: FEDERAL POWER COMMISSION, "NEWS RELEASE" MONTHLY.

CONSUMPTION OF ELECTRIC ENERGY BY ULTIMATE CONSUMERS-IOWA
(MIL. KWH)

FIGURE 6-8

VII RELATIONSHIP BETWEEN SHORT-TERM USES OF MAN'S ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

7.01 Short-Term Relationship. The production of electric power and the utilization of related resources over the expected 30-year life of the Ottumwa Generating Station is considered short-term use.

7.011 The short-term benefit of the Ottumwa Generating Station will be a capacity adequate to meet the electric power requirements of the owner utilities, Mid-Continent Area Power Pool Members and Mid-Continent Area Reliability Coordination Agreement Region. The additional electrical energy will be available throughout the service area to residential users, commerce, industry, agriculture, public service, and recreation. The added capacity of Ottumwa Station will provide greater system reliability and reduce the probability of system disturbances.

7.012 There will be other short-term benefits associated with the construction phase. These benefits will include the creation of new jobs, the expansion of local commerce and related secondary economic activities, and a growth in the local tax base. Such beneficial impacts will result from the establishment of the new facility as well as from increased payrolls and business activity.

7.013 Some adverse, short-term impacts will be associated with the construction activities of the generating facility. There will be some unavoidable contributions of turbidity of the Des Moines River during the construction of the intake structure, increased noise levels, and some decrease in air quality. These impacts are discussed in Section 4.01, page IV-1.

7.02 Long-Term Relationship. Long-term productivity refers to the resource development potential which remains after the life span of the Ottumwa Generating Station.

7.021 The long-term maintenance of productivity potential should be preserved in the areas of water quality of the Des Moines River, aquatic biota, and ambient air quality since the Ottumwa Generating Station must comply with stringent federal and state regulations. The maintenance of these resources has been discussed in previous chapters of this report.

7.022 The most significant long-term effect of the proposed project would be an increase in human productivity stimulated by the availability of additional electric power. This may result in increased development in the service areas of the owner utilities.

VIII IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

8.01 General. The construction and operation of the Ottumwa Station would result in the irreversible or irretrievable commitment of some natural resources. These resources either would be expanded or altered to the extent that they could not be restored for later use.

8.02 Fuel. The fossil fuel used to operate Ottumwa Station will be the principal irreversible commitment of natural resources. From 1.9 to 2.7 million tons of coal will be used annually as well as approximately 250,000 gallons of fuel oil for initial light-off and flame stabilization. During the estimated 30-year life of the generating station from 57 to 81 million tons of coal and about 7,500,000 gallons of oil will be burned for fuel.

8.03 Land. Much of the land resources presently used for agricultural purposes will not be available during the 30-year expected life of the generating facility. Some of the land on the 795 acre site, however, will be leased for farming activities while the generating station is in operation when possible.

8.04 Water. Water withdrawn from the Des Moines River for condenser cooling and other plant uses will be a consumptive use. Water withdrawal from the river will be at an estimated rate of 11,091,000 gallons per day (about 17 cfs) or 4,061,355,000 gallons per year for the maximum operating condition, and 7,834,000 gallons per day (approximately 12 cfs) or 2,859,410,000 gallons per year for the average operating condition. Over the 30-year life of the generating station a calculated amount of 121,840,650,000 gallons will be withdrawn for maximum operating conditions, and 85,782,300,000 gallons will be withdrawn for average operating conditions. These calculations are based on plant operations for 365 days a year and represent maximum values. Actual water usage will be less. The average and maximum operating conditions are defined in Section 1.044 of this report. The amount of water discharged back to the Des Moines River is estimated to be 889,000 gallons per day or 324,485,000 gallons per year at maximum operating conditions, and 700,000 gallons per day or 255,500,000 gallons per year at average conditions.

8.05 Biological. Vegetation removed for construction would be irretrievably lost, although grasses, shrubs, and trees would eventually become re-established if the structures were removed. Small aquatic organisms present in the river water withdrawn for plant use would be lost. Some other larger organisms may be impinged and injured or eliminated. Aquatic organisms, however, are a renewable resource in that they would be eventually replaced. Phytoplankton and zooplankton would be replaced in a matter of days, while benthic fauna and fish fauna would be replaced over a period of months and years.

8.06 Energy. Although calculating the quantity of materials expended in the construction of OGS is indicative of the direct commitments of material resources, the calculation of the indirect commitments, such as the energy needed to produce the steel that is used to make the machinery which forges and fabricates the steel used in OGS, is also necessary. The energy resources associated in manufacturing these materials are important since the direct recovery of this energy in its natural form cannot be accomplished.

8.061 Several methods have been devised in computing the indirect energy commitments and account for the energy per dollar used in manufacturing materials for construction. The method used for this study was devised by Rombough and Koen[1] in either calculation of the total energy investment to construction of a 1000 MW coal-fired power plant[2]. Their approach, which considers all indirect as well as direct energy commitments, is formulated on the basis of an average energy/cost ratio for the United States. This ratio is determined by dividing the total energy consumed in the U.S. in a given year by the gross national product of the same year. Multiplying this average energy/cost ratio times the cost of construction (in dollars) results in a rough estimate of the total construction energy cost.

8.062 Adapting this approach to OGS (727 MW unit) at an estimated construction cost of \$250,000,000, the resulting total energy commitment to construction, based on 1972 average energy/cost ratio of 62,413 Btu/dollar[3], is 0.15×10^{14} Btu. Adding the total energy committed to construction to the estimated 15.28×10^{14} Btu expended in OGS lifetime plant operation, the result is a gross value of 15.44×10^{14} Btu consumed. Subtracting 5.21×10^{14} Btu of electrical energy produced in the plant's lifetime from the gross value, a net energy expenditure of 10.22×10^{14} Btu is obtained.

8.063 Therefore, during a 30-year period of station operation at 80 per cent capacity, the energy committed to construction is 1.0 per cent of the total energy expenditure or 2.9 per cent of its total electric generation. The net energy output of the plant is 34 per cent of the total energy expenditure (construction plus operation).

8.07 Other Commitments. Construction materials would be comprised primarily of concrete, steel, aluminum, copper, zinc, lead, lumber, insulation, and asphalt. These materials essentially would be unavailable for further use. Some materials used to construct transmission towers and lines could be utilized for other purposes.

8.071 The electricity produced by the facility would be a man-made resource which, once used by man, would be irretrievable.

REFERENCES

1. Rombough, Charles T., and Koen, Billy V., "Total Energy Investment in Nuclear Power Plants," Nuclear Technology, Vol. 26, Number 1, pp. 5-11, (May 1975).

2. "1000 MW(e) Central Station Power Plants Investment Cost Study," Vol. III, "Coal-Fired Fossil Plant," United Engineers and Constructors, Inc., U.S. Atomic Energy Commission, Washington, D.C., (1972).

3. "Statistical Abstract of the United States - 1974," U.S. Department of Commerce, Bureau of the Census, Washington, D.C., (1974).

IX COORDINATION AND COMMENT AND RESPONSE

9.01 Consultants. Engineering data and an evaluation of various probable impacts that would result from the construction and operation of the Ottumwa Generating Station in Wapello County, Iowa were prepared by Black & Veatch Consulting Engineers, Kansas City, Missouri. The following expert consultants contributed to the environmental studies as indicated.

Air Quality Analyses	Dr. C.W. Langston, Mr. W.D. Hughes Langston Laboratories, Inc., Leawood, Kansas.
Archaeological Studies	Mr. D.C. Anderson, Iowa State Archaeologist, Iowa City, Iowa. Mr. M.S. Weichman, Environmental Research Center, Iowa City, Iowa.
Aquatic Studies	Dr. D.B. McDonald, Iowa Institute of Hydraulic Research, University of Iowa, Iowa City, Iowa.
Benthic Studies	Dr. W.B. Merkley Drake University, Des Moines, Iowa.
Terrestrial Studies	Dr. D.C. Glenn-Lewin Iowa State University, Ames, Iowa.

9.02 Government Agencies and Officials. The following federal, state, county and local agencies and individuals have been notified by the applicant and its contractor concerning the proposed plans to construct and operate the Ottumwa Generating Station.

*Iowa Department of Environmental Quality
3920 Delaware Avenue
Des Moines, Iowa

*Iowa Natural Resources Council
Grimes Building
Des Moines, Iowa

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*Indicates those agencies to which applicant and contractor have held meetings.

*Iowa Conservation Commission
4th and Walnut
Des Moines, Iowa

Iowa Commerce Commission
4th and Walnut
Des Moines, Iowa

Commissioner of Public Health
Iowa State Health Department
Lucas State Office Building
Des Moines, Iowa

*Iowa State Department of Health
State Hygenic Laboratory
Iowa City, Iowa

Soil Conservation Committee
Grimes Building
Des Moines, Iowa

*Iowa State Archaeologist
129 S. Capitol Street
Iowa City, Iowa

Department of Transportation
Ames, Iowa

Iowa Historical Society
Iowa City, Iowa

*Office for Planning and Programming
Capitol Building
Des Moines, Iowa

*Iowa Development Commission
250 Jeweff Building
Des Moines, Iowa

*Center for Industrial Research and Service
Iowa State University
Ames, Iowa

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*Indicates those agencies to which applicant and contractor have held meetings.

*Iowa State Geologist
Iowa Geological Survey
Iowa City, Iowa

*Mr. Bruce Bullamore
Planning Director
Area XV Regional Planning Commission
Ottumwa Industrial Airport
Ottumwa, Iowa

*Mr. Dale Euhling
County Agent
County Extension Service
211 E. Second Street
Ottumwa, Iowa

*Mr. Jay Pulis
Planning Director
City Hall
Ottumwa, Iowa

*Mr. H.S. (Biff) Byrum
Ottumwa Area Development Corporation
Hotel Ottumwa Building
Ottumwa, Iowa 52501

Wapello County Board of Supervisors
Wapello County Court House
Ottumwa, Iowa

*Mr. Hugh Stufflebeam
Mayor
City Hall
Ottumwa, Iowa

*Mr. Marvin Ferdig
Mayor
Chillicothe, Iowa

*U.S. Corps of Engineers
Rock Island District Office
Rock Island, Illinois

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*Indicates those agencies to which applicant and contractor have held meetings.

9.03 Coordination Meetings. Coordination meetings by the applicant or the applicant's consultants have been held with the following agencies.

AGENCY	DATE
U.S. Corps of Engineers Rock Island District Rock Island, Illinois	January 16, 1975; March 10, 1975; June 4, 1975
Iowa Natural Resources Council Des Moines, Iowa	April 3, 1975; June 17, 1975; December 10, 1975
Iowa Conservation Commission Des Moines, Iowa	April 7, 1975
Center for Industrial Research and Service, Iowa State Univ. Ames, Iowa	April 8, 1975
Iowa Institute of Hydraulic Research, University of Iowa, Iowa City, Iowa	April 9, 1975
Iowa State Hygenic Laboratory Iowa City, Iowa	April 9, 1975
U.S. Geological Survey Iowa City, Iowa	April 9, 1975
Iowa Geological Survey Iowa City, Iowa	April 9, 1975
U.S. Soil Conservation Service Ottumwa, Iowa	April 10, 1975
County Agent, Wapello County Extension Office Ottumwa, Iowa	April 10, 1975

AGENCY	DATE
State Historical Department of Iowa, Division of Historical Preservation Iowa City, Iowa	July 22, 1975

On June 23, 1976 the U.S. Environmental Protection Agency, with the support of Iowa Southern Utilities and their contractor, Black & Veatch Consulting Engineers held a public information meeting for the dual purpose of describing the intent and current status of the Ottumwa EIS, and of gaining early public input.

9.04 Permit Applications. Applications for the following permits have been submitted or will be submitted in the future.

AGENCY	PERMIT	STATUS (December 1976)
U.S. Army Corps of Engineers	Permit to work in Navigable Waters	Application filed October 31, 1975
U.S. Environmental Protection Agency	NPDES Permit	Application filed October 31, 1975
Federal Aviation Administration	Determination of no hazard to air navigation	Determination made July 30, 1976
Iowa Department of Environmental Quality	Water Quality Certification	To be submitted
	Permit to construct wastewater disposal system	To be submitted
	Solid waste disposal area permit	To be submitted

AGENCY	PERMIT	STATUS (July 1976)
	Permit to install air pollution equipment	Specifications for precipitator, steam generator, coal-handling system, chimney submitted
	Operating permit	No action
Iowa Natural Resources Council	Permit to divert, store, or withdraw water	Application filed December 15, 1975
	Permit to construct facilities in flood plain	Tentatively approved January 6, 1976
Iowa Commerce Commission	Franchise to construct, operate and maintain transmission line	To be submitted
Iowa State Department of Health	Approval of sewage treatment plant plans and specifications	To be submitted
Iowa Conservation Commission	Construction permit	Approved May 21, 1976
U.S. Environmental Protection Agency	Approval to construct in compliance with Prevention of Significant Deterioration Regulations	Approved December 1, 1976

APPENDIX A

ARCHAEOLOGICAL INVESTIGATIONS IN THE PROPOSED AREA OF THE OTTUMWA GENERATING STATION CHILLICOTHE, IOWA

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ACKNOWLEDGEMENTS

Archaeological sites 13WP13, 13WP14, 13WP22, 13WP25 and 13WP85 were tested in the spring of 1975. Richard G. Slattery of the Office of State Archaeologist was field director. He was assisted by Arthur E. Hoppin, John Sanderson Stevens II, Lawrence Ryan and at times by Don G. Spears. Site mapping was assisted at one point by John Hotopp. Office of State Archaeologist and Derrick J. Marcucci, anthropology student, University of Iowa. After field work was completed, the task of researching, describing and interpreting the sites and materials was undertaken by the author.

Thanks are due to the many people who contributed to this report: Duane C. Anderson, Joseph A. Tiffany, and Richard G. Slattery, Office of State Archaeologist; Todd Mozingo and Lowell Soike, Division of Historic Preservation; Joyce Giaquinta and Alan Schroder, Division of the State Historical Society of Iowa; David M. Gradwohl and Nancy Osborn, Department of Anthropology, Iowa State University; Carroll Truitt of the firm of McElroy, Truitt and Truitt, Ottumwa; Don G. Spears and Lawrence Ryan, Southeast Chapter, Iowa Archeological Society; Anton Till, Division of Historic Preservation, Field Archaeologist; Dennis Davis and Thomas Armitage, Ottumwa Public Library; W. Sinclair Venables, Wapello County Historical Society, Ottumwa; Vivian Jones, Eddyville; and Mrs. P. Darner, Ottumwa.

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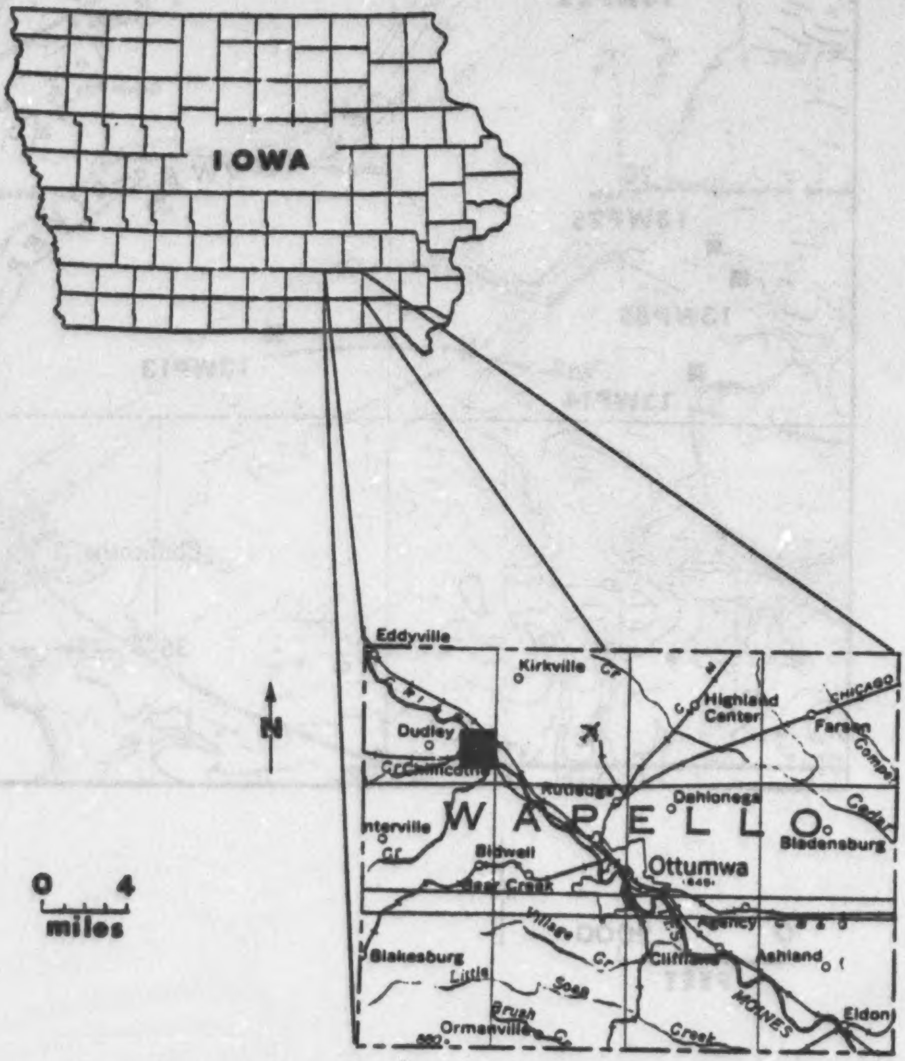
INTRODUCTION

The Office of State Archaeologist, The University of Iowa, entered into agreement with the firm of Black & Veatch, representing Iowa Southern Utilities (ISU), for the purpose of conducting archaeological investigations in the vicinity of the ISU Generating Station under construction near Chillicothe, Iowa (Fig. 1).

Phase I surface reconaissance survey by Weichman (1975) revealed thirteen archaeological sites in the project area. The Office of State Archaeologist was subsequently contracted to provide Phase II testing and evaluation and Phase III salvage. The results of Phase II testing and evaluation were submitted in a 1975 report (Slattery and Tandarich 1975) at which time recommendations concerning further work (Phase III) were made. Sites 13WP13, 13WP14, 13WP22 and 13WP25 were recommended for Phase III archaeological work. During the Phase III operations conducted in March and April, 1976, an additional prehistoric site, 13WP85, was discovered and investigated. This report will describe the findings of Phase III archaeological work at the five sites mentioned above.

The locations and topographic situation of the five sites to be discussed in this report are shown on Figs. 2-4. Sites 13WP13, 13WP14 and 13WP85 are prehistoric, while sites 13WP22 and 13WP25 are historic Euro-American.



■ Project Area (see Fig. 2)

Figure 1. Location of Project Area within Wapello County, Iowa. USGS Iowa Base Map, scale 1:500,000.

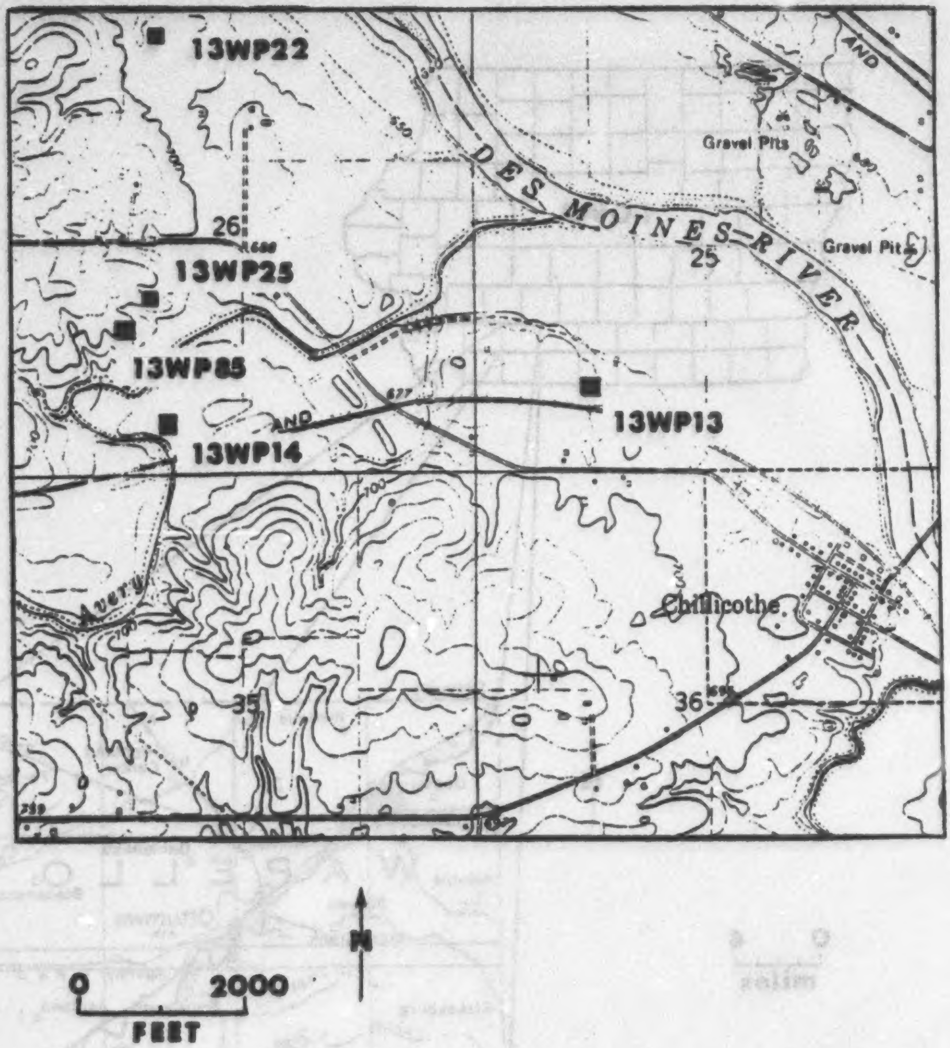


Figure 2. Location of sites discussed within this report. USGS Chillicothe Quadrangle Map, scale 1:24,000.

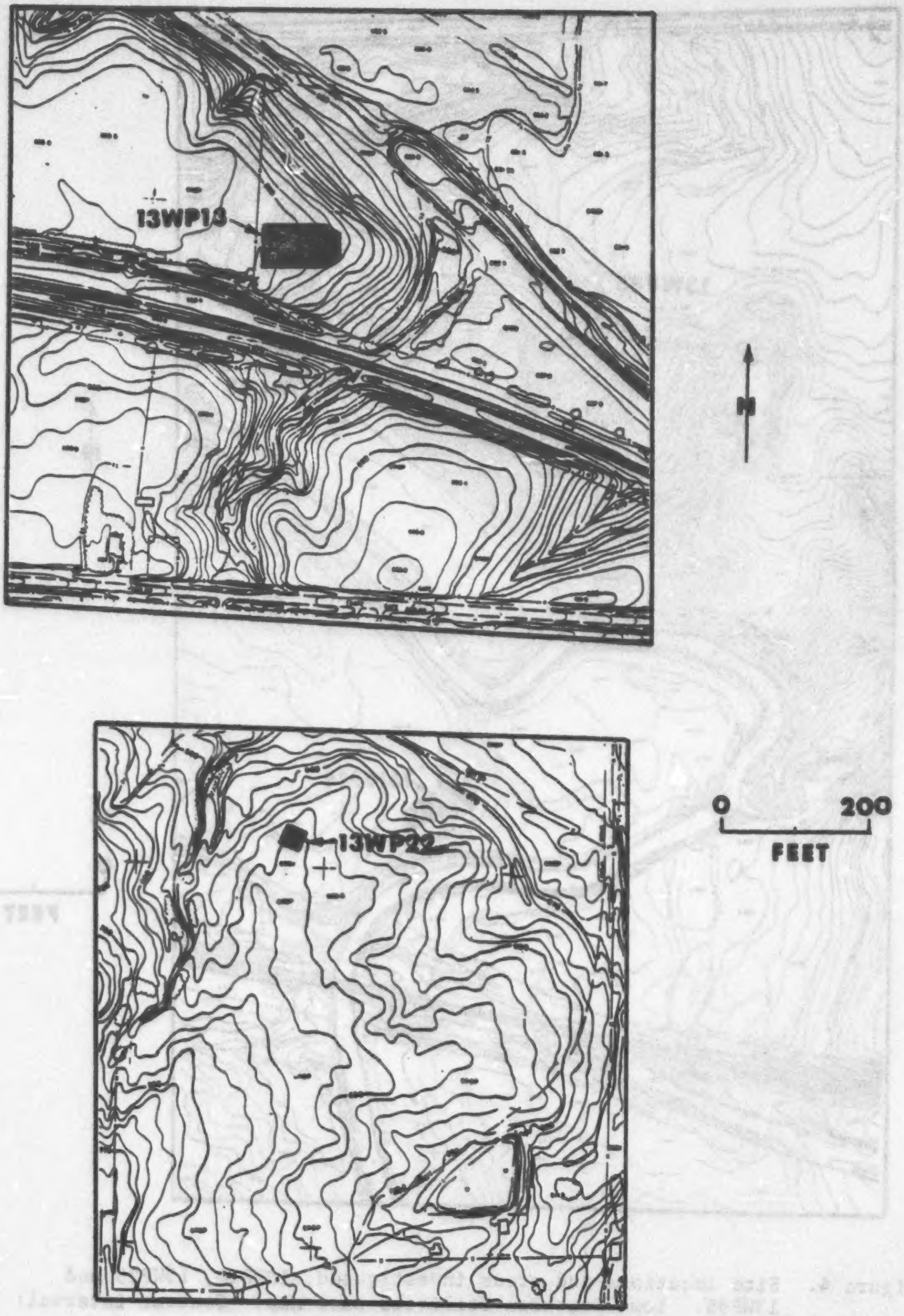


Figure 3. Site locations and areas investigated, 13WP13 (above) and 13WP22 (below). Iowa Southern Utilities Base Map. Contour interval: 2 feet.

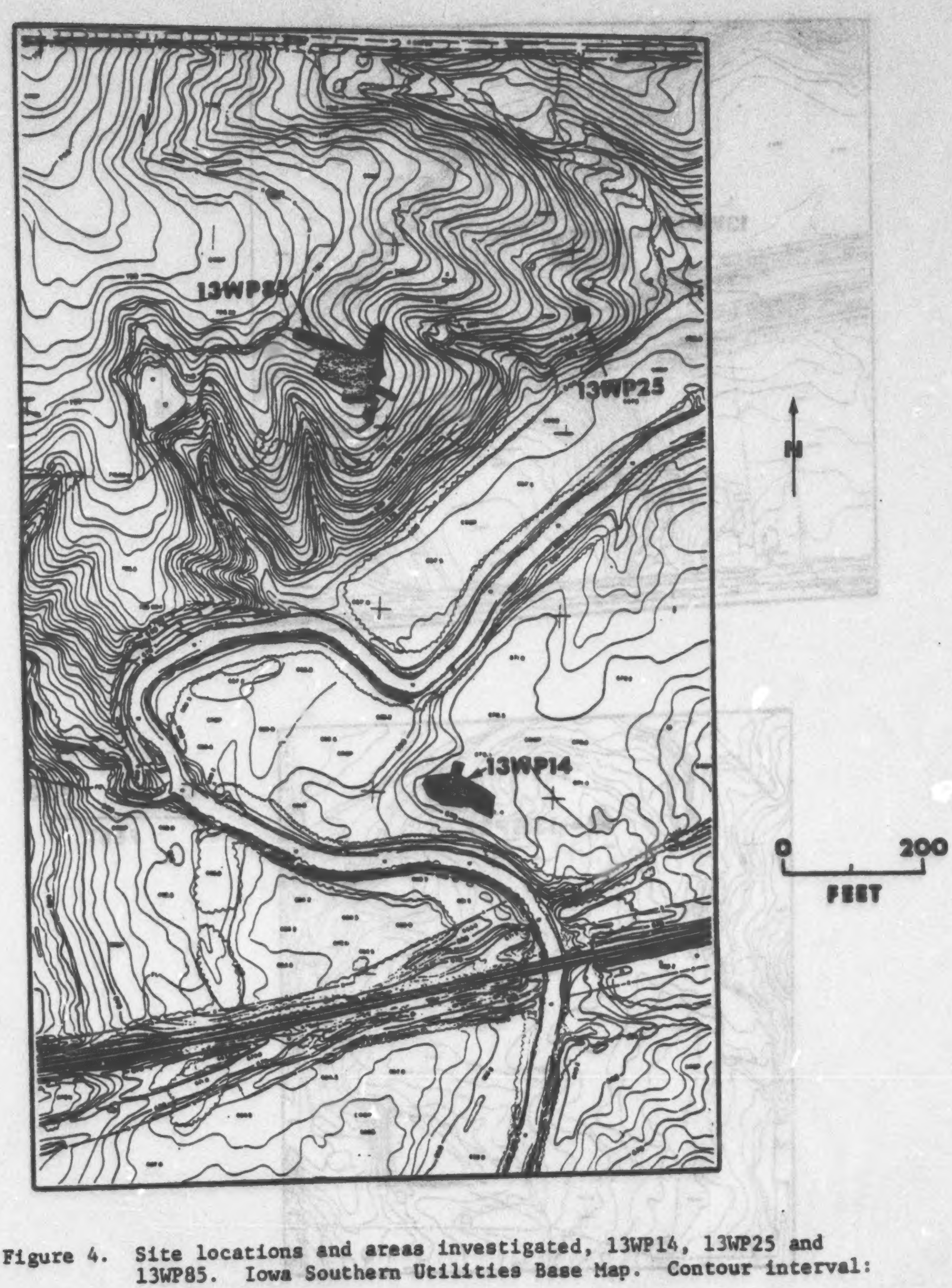


Figure 4. Site locations and areas investigated, 13WP14, 13WP25 and 13WP85. Iowa Southern Utilities Base Map. Contour interval: 2 feet.

Prior to the initiation of Phase III activities, plans were made to clear all or part of the plowzone on each site in an effort to determine if subsurface features were present. In so doing, an attempt was made to recover a material culture inventory sufficient to allow for a determination of the cultural affiliation and use of each of the sites. Depending on the results of testing, the field supervisor was prepared to investigate structures, activity areas, refuse deposits, or other pertinent features. Specific methods and techniques employed on each site are described in context within the body of this report.

Although the prehistoric sites were known to be shallow and heavily disturbed by cultivation, they were believed to be campsites. This interpretation was borne out by the Phase III investigations. However, few diagnostic artifacts were found and none of the features investigated yielded climatic or environmental information. As a result, this report is speculative in terms of the interpretation of the prehistoric sites investigated.

In the case of the historic sites, particular attention was given to the site plan following the research strategy outlined by Price and Price (1976 ms). This proved to be a useful approach since one of the historic sites investigated was found to be a farmstead and the other is believed to represent a portable steam saw mill.

During the laboratory phase the research strategy for dealing with the historic sites was refined with the assistance of Loren N. Horton, State Historical Society of Iowa. In order to ascertain the dates of construction of the structures, their possible occupants and the length of occupation, a list of original historical sources was prepared and entries were ranked in order of priority (Table 1). The results of this research are presented in this report.

Table 1: Priority Ranking of Historical Research Sources

Rank	Location	Source Depository	Sources
1	Iowa City	State Hist. Soc.	Historical Map File, atlases Geol. Survey Ann. Rept., Maps
	Ames	DOT I.S.U. Map Coll.	Road Records and Maps W.P.A. Maps
2	Des Moines	Sect'y of State	Government Land Office Surveys
	Ottumwa	Wapello Co. Recorder of Deeds McElroy, Truitt & Truitt (abstractors)	Land Transfer Books, Plats
3	Ottumwa	Wapello Co. Board of Supervisors.	Minutes of Board Meetings Records for cemeteries, bridges, roads
4	Iowa City	State Hist. Soc.	County histories, state histories, Census
	Ottumwa	Public Library	Centennial histories of nearby towns, city directories
		Wapello Co. Hist. Soc.	Oral tradition & misc. info.
5	Ottumwa	Public Library	Newspaper accounts in scrapbooks, microfilm
6	Ottumwa	County Treasurer &/or Recorder's Office	Tax rolls 1857
7	Iowa City	Univ. of Iowa Libraries, Gov. Docs.	Soil survey maps (old)
8	Iowa City	State Hist. Soc.	Photograph coll., mss. catalog, vertical file, post card coll.
		University of Iowa Libraries, Special Coll.	W.P.A. Records, archival material
	Des Moines	Division of Historical Museum and Archives	Manuscripts
	Ottumwa	Public Library	J.P. Eddy's Diary

Source: Loren N. Horton (personal communication) and author's research.

THE PREHISTORIC SITES
13WP13, 13WP14 and 13WP85

Three prehistoric sites have been extensively examined: 13WP13, 13WP14 and 13WP85. The locations of these three sites are shown on Figs. 2-4.

Site Plans

Portions of all three sites were scraped to the subsoil by a roadgrader during Phase II operations. During Phase III the entire site areas were cleared allowing a full view of soil color changes and subsurface features, and enabling a representative collection of artifactual items to be made.

All exposed features on the prehistoric sites were surveyed and mapped *in situ* with a transit. The maps so produced are displayed on Figs. 5, 6 and 7.

13WP13

Five hearths containing fire cracked rocks were uncovered (Fig. 5). Although the soil surrounding these rock concentrations was not burned, many of the stones were. Of a total sample of 38 rocks recovered from these concentrations 50% were burned (see Table 3, Miscellaneous Unworked Material). An ash layer and two areas of charcoal were also observed (Fig. 5).

13WP14

Six probable post molds were recognized on the site (Fig. 6). No concentrations of fire-cracked rock or hearths were observed as on 13WP13. There appeared to be an activity area located around post 2 consisting of: 1 piece of worked limestone, 1 hematite core fragment, 2 heamtite waste flakes, 1 chert biface fragment (12)*, 2 chert waste flakes (1), 1 chert waste flake (14) and 2 chert core fragments (5). Four projectile points, one knife and one celt were also mapped on the site (Fig. 6).

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*Numbers in parentheses refer to lithic color categories, see section on *Material Culture Inventory*.

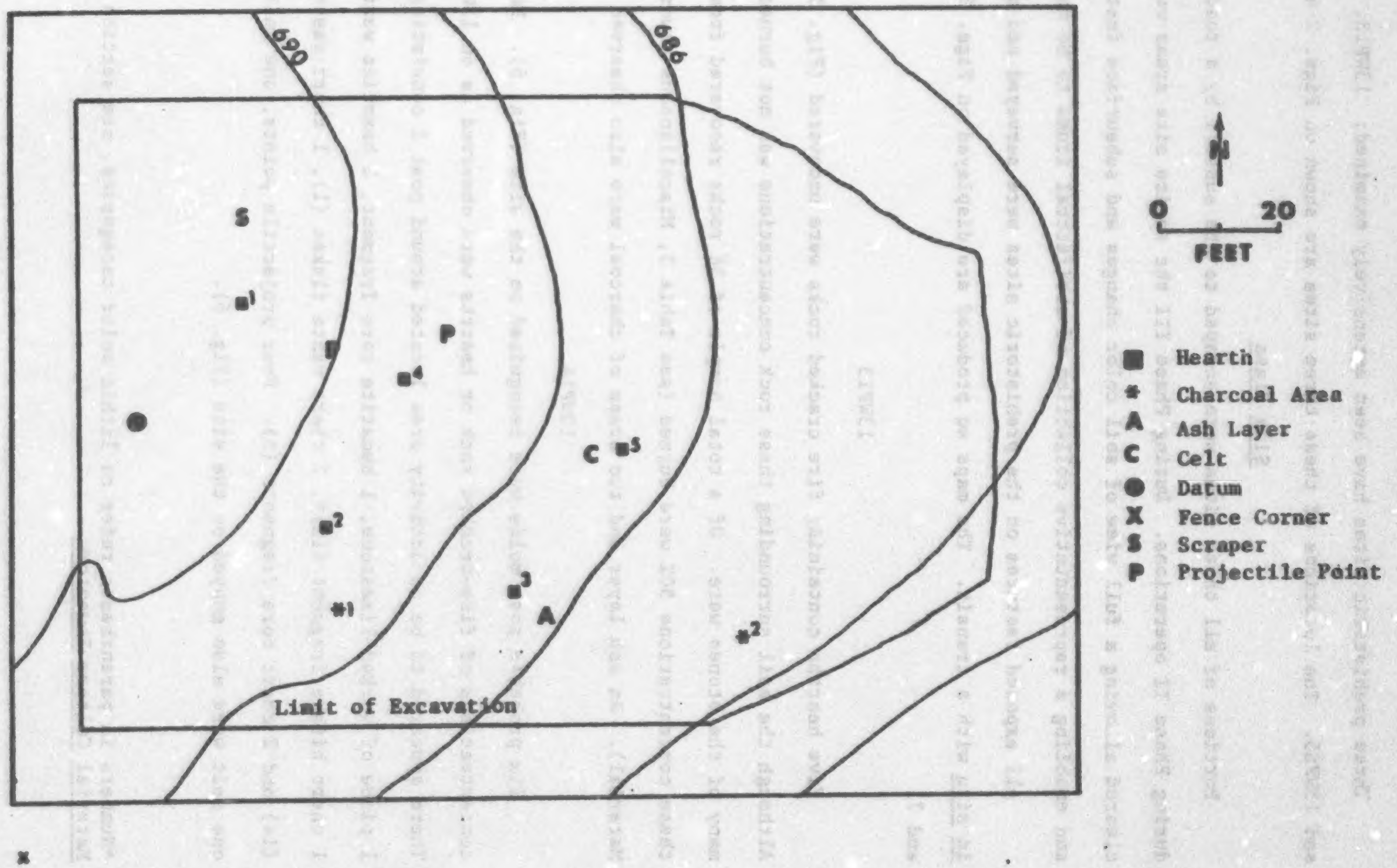

Figure 5. Site Plan, 13WP13.
Source: Slattery (1976c ms.)

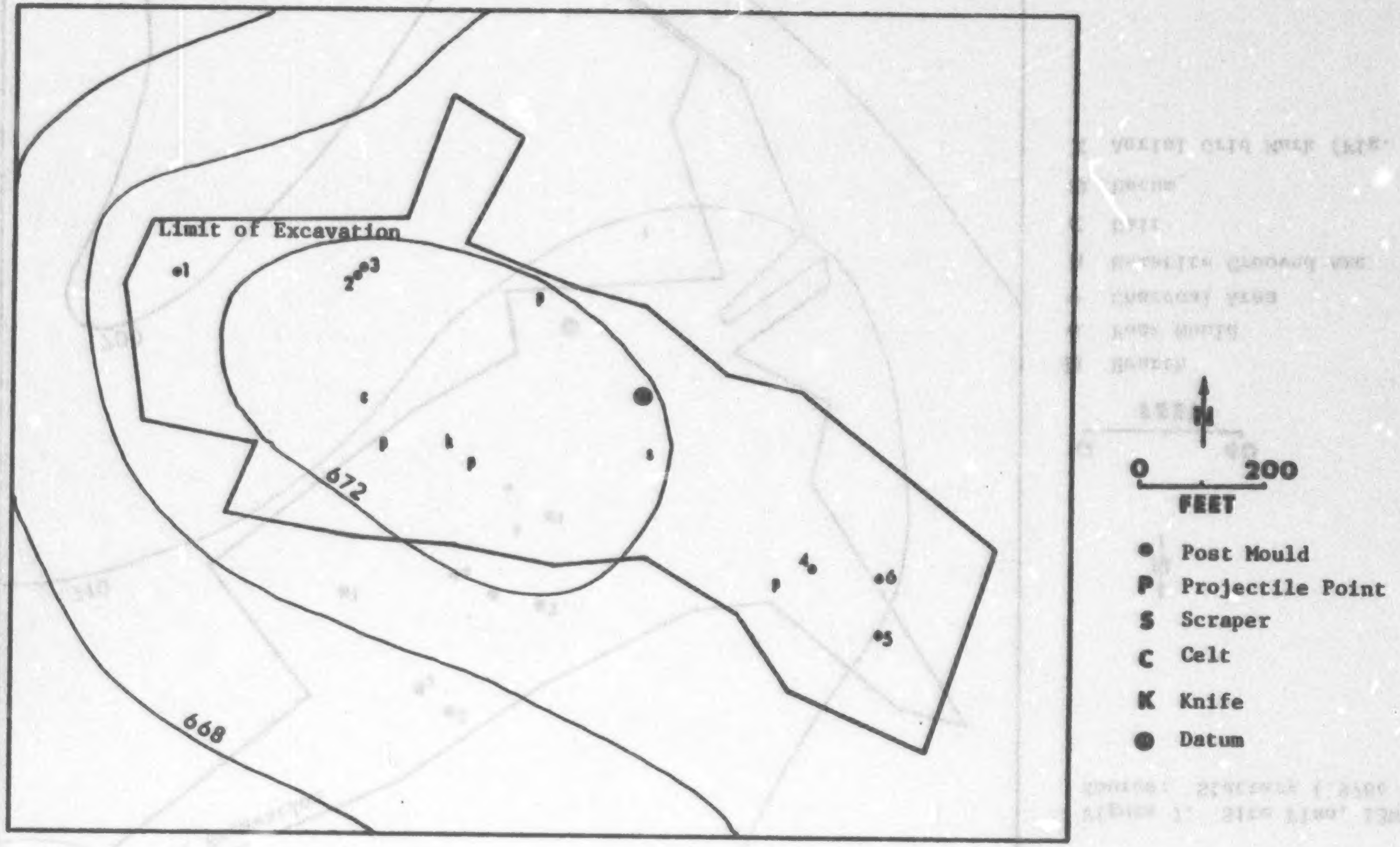

Figure 6. Site Plan, 13WP14.
Source: Slattery (1976c ms.)

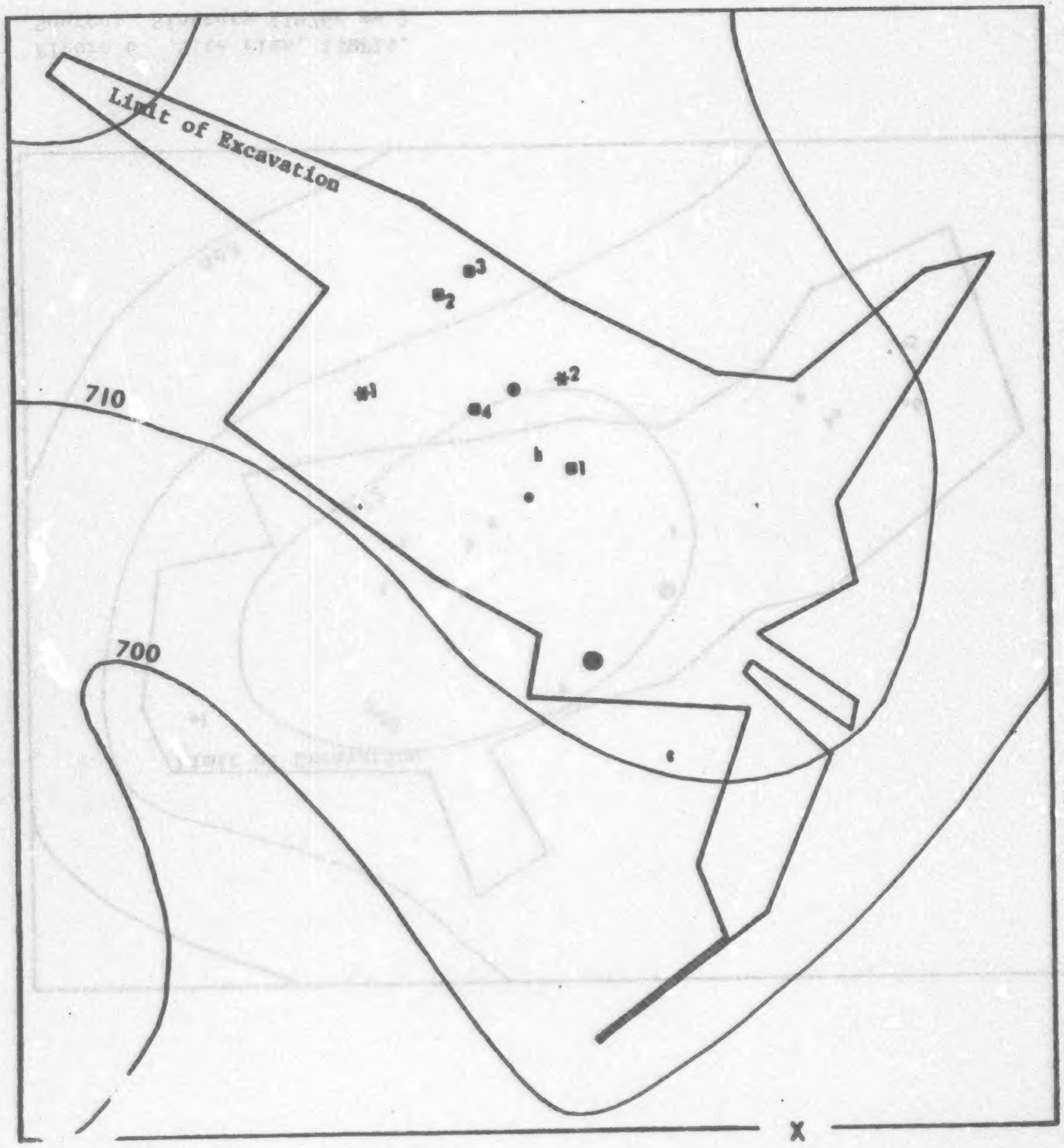

Figure 7. Site Plan, 13WP85.
Source: Slattery (1976c ms.)

13WP85

Four hearths consisting of fire cracked and burned rock and earth were mapped (Fig. 7). Samples of material from three of the hearths were brought to the laboratory for identification (Table 2).

Table 2: Identification of Hearth Materials from 13WP85

Fragment Type	Hearth 1		Hearth 2		Hearth 3	
	unburned	burned	unburned	burned	unburned	burned
sandstone		24		7		2
siltstone		7	9	3		34
granite				7		

Source: R. S. Rhodes, personal communication.

Hearth 2 had a chipping area one foot from center on the northwest side. "Thirty four waste flakes were found in a concentrated area of 6 x 6 ins. including five waste flakes. . . on the east side of the hearth" (Slattery 1976 ms:13). In addition, two areas of charcoal and two apparent post molds were located (Fig. 7).

Material Culture Inventory

In order to analyze and inventory lithic materials from the three prehistoric sites, a number of categories were established based largely on color (cf. Anderson 1973). The inadequacy of this method is recognized. Geologic descriptors would be more useful than color, e.g., structure, fracture, texture, fossil and other inclusions, etc., for analyzing chert types. For gross description in this report, color will serve as a means to compare the lithics collected from the sites. Color descriptions were determined from the Rock Color Chart (Rock Color Chart Committee 1963).

1. Dark reddish brown (10 R 3/4) chert
2. Pale reddish brown (10 R 5/4) to moderate reddish orange (10 R 6/6) chert
3. Light brown (5 YR 6/4) to pale yellowish brown (10 YR 6/2) chert
4. Pale yellowish brown (10 YR 6/2) to grayish orange (10 YR 7/4) chert
5. Light olive gray (5 Y 6/1) to olive gray (5 Y 4/1) chert
6. Medium gray (N5) to brownish gray (5 YR 4/1) chert.
7. Medium gray (N5) to brownish gray (5YR 4/1) (as category 6) to grayish red (5 R 4/2).
8. Medium bluish gray (5 B 5/1) chert.
9. Medium bluish gray (5 B 5/1) to grayish red (5 R 4/2) chert
10. Very light gray (N8) to light bluish gray (5 B 7/1) chert.
11. Very light gray (N 8) to light bluish gray (5 B 7/1); to pale red (10 R 6/2) chert.
12. Very pale orange (10 YR 8/2) chert.
13. Very pale orange (10 YR 8/2) to grayish orange (10 YR 7/4) chert.
14. White (N9) chert.
15. Pale pink (5 RP 8/2) chert.
16. Multicolor speckled chert.
17. Multicolor banded chert.

18. Very light gray (N8) to light gray (N7) chert.

19. Pale yellowish brown (10 YR 6/2) speckled chalcedony?

20. Pale red (10 R 6/2) to moderate reddish orange (10 R 6/6) quartzite.

21. Vein (cloudy) white (N9) quartz.

22. Clear quartz.

23. Multicolor quartz.

24. Light olive gray (5Y 6/1) chalcedony.

25. Pale reddish brown (10 R 5/4) chalcedony.

LITHICS

Several diagnostic chipped stone artifacts were recovered from the prehistoric sites. This material is listed below and illustrated where appropriate. Inspection has been used to classify the artifacts into particular traditions. The main reference utilized for this study is White (1968). Artifacts recovered during Phase II activities are described and illustrated by Slattery and Tandarich (1975:5-9, 44).

13WP13

Side notched projectile point base, chert category 11, probable Ansell constricted-stemmed type(White 1968:Fig. 32-4), Late Hopewell chronology. A.D.300.-A.D.650 in Illinois. (Ibid.:14, 121). (Fig. 8A).

End scraper, chert category 12. (Fig. 8).

Hematite celt fragment. (Fig.8c).

Projectile point resharpened into a scraper, chert category 16, probably originally a Gibson notched (White 1968:Fig.32-3), Early to Middle Hopewell chronology in Illinois, 200 B.C.-A.D.300 (Ibid.: 14, 121). (Fig. 8).

13WP14

Point base, chert category 10, probable micro-Dickson type (White 1968:Fig.62-2), Late Middle Woodland (Hopewellian) chronology in Illinois, A.D. 300-600 (Ibid.:14,162). (Fig. 9A).

End scraper, chert category 14. (Fig. 9B).

Point base, chert category 4, resembles a subtriangular stemmed point discussed by White (1968:Fig.31-8), appears to be contemporaneous with Gibson and other Early to Middle Hopewell point types in Illinois, i.e., 200 B.C.-A.D.300 (Ibid.:14, 121). (Fig. 9C).

Partial side-notched point base, chert category 6, not enough of the point present to classify. (Fig. 9D).

Partial point blade and contracting stem base, chert category 16, resembles a Waubesa (Adena) though the stem is much shorter than typical Waubesa point, chronology is probably Early Woodland, 500-250 B.C. (White 1968:Fig.65). (Fig.9E).

Lanceolate point, chert category 10, edge ground on one side, resembles a Nebo Hill variant (Chapman 1975: Figure 604, lower row, third from right). Early Archaic in chronology 700 B.C.-5000 B.C. (Chapman 1975:27). (Fig 9F).

Hematite celt fragment. (Fig. 8E).

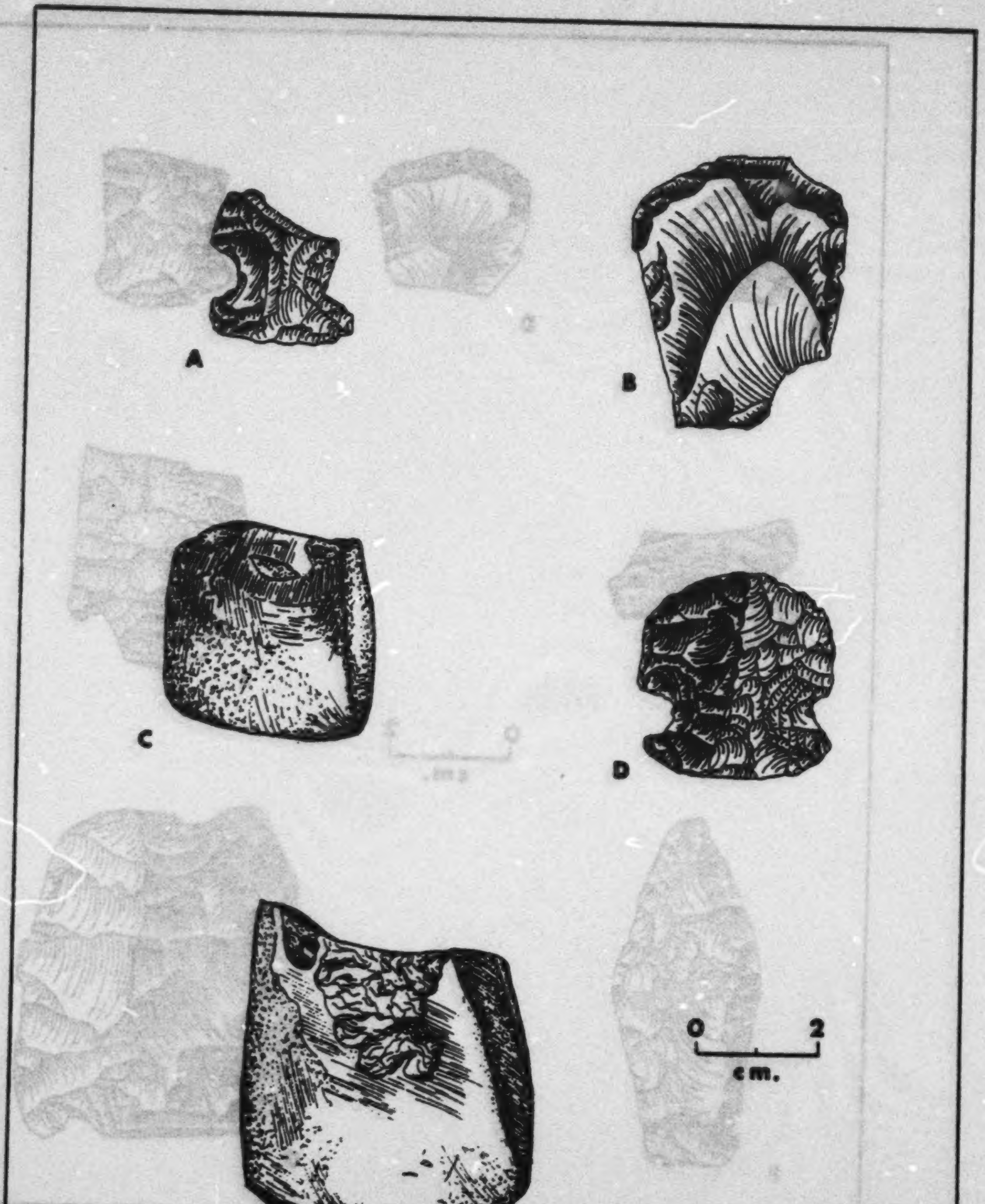

Figure 8. Chipped and ground stone artifacts from 13WP13 and 13WP14. A-D, 13WP13; E, 13WP14.

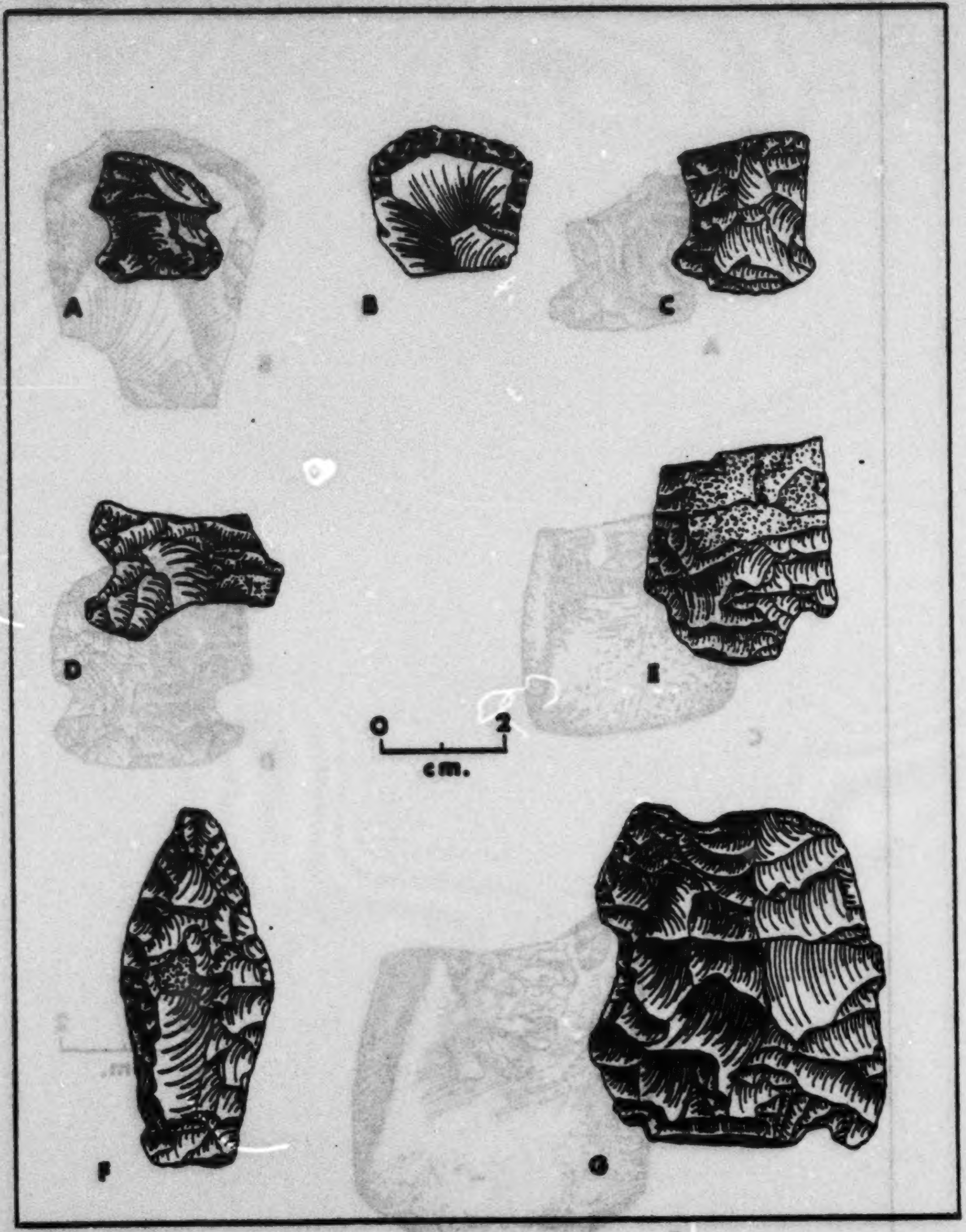

Figure 9. Chipped stone artifacts from 13WP14.

13WP85

Subtriangular stemmed point base, chert category 16, very similar in form and chronology to subtriangular point from 13WP14 (see above). (Fig. 10A).

Subtriangular point, chert category 12, resembles a point type from the Manker site in Illinois (White 1968:Fig.60-6). Probable chronology is Late Middle Woodland A.D. 300-550 (Ibid:14). (Fig. 10B).

Hematite celt fragment. (Fig. 10C).

Full grooved, hematite axe fragment. (Fig. 10D).

Non-diagnostic chert and hematite material recovered, has been summarized in Table 3. A detailed breakdown of non-diagnostic lithic material utilizing color categories established is presented in Table 4.

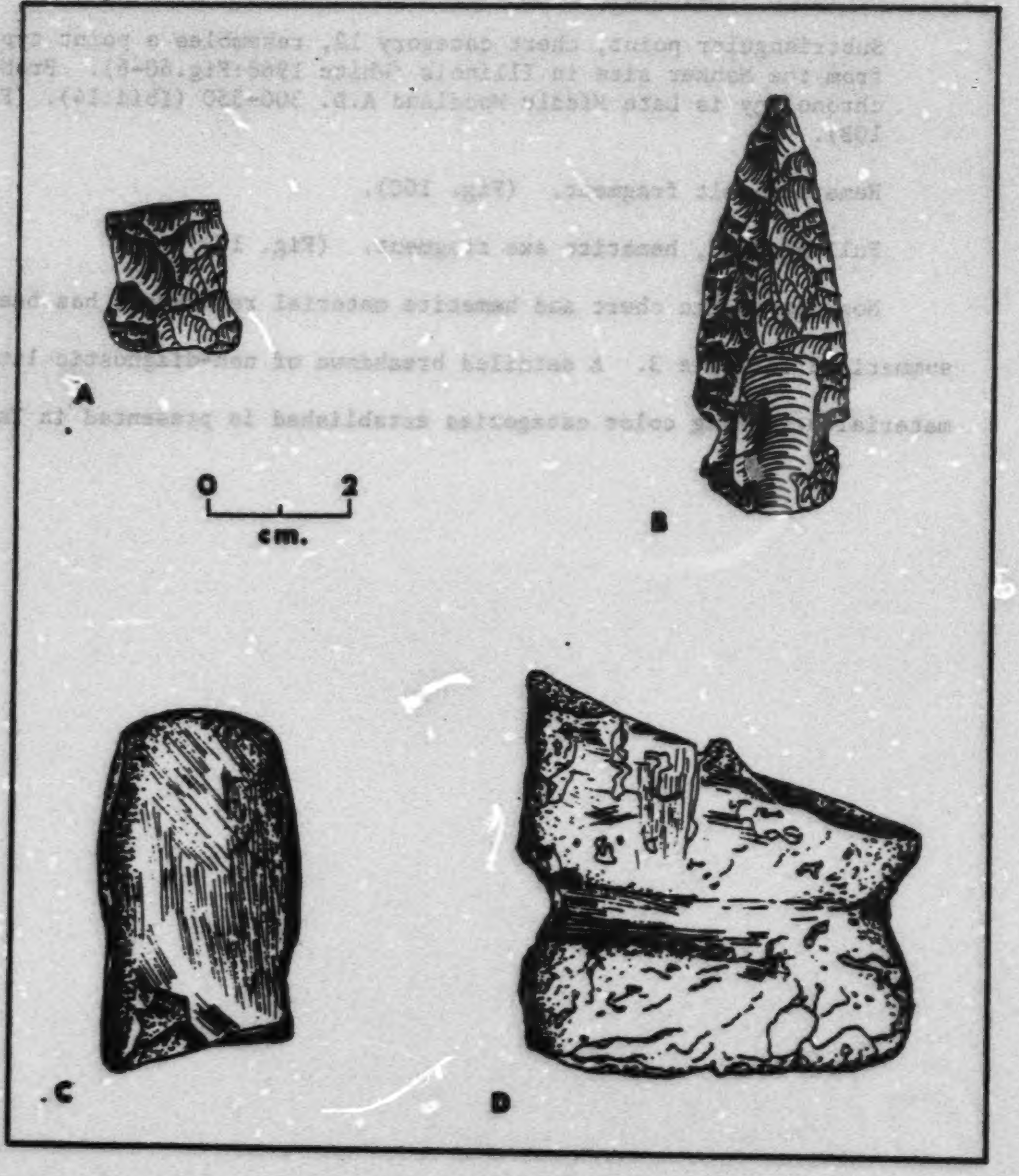

Figure 10. Chipped and ground stone artifacts from 13WP85.

Table 3: Frequency Distribution of Lithic Material.

	13WP13	13WP14	13WP85
CHERT			
Chipped Artifacts			
Bifaces and biface fragments	7	12	11
Retouched flakes	9	13	4
Retouched cores and core fragments		3	
Utilized flakes	8	10	6
Utilized core and core fragments	5	1	2
Preforms		1	
Debitage			
Waste flakes	350	209	299
Cores	2	11	14
Core fragments	137	67	48
HEMATITE			
Chipped Artifacts			
Bifaces and biface fragments	4	8	3
Preforms	2		
Ground and Polished Artifacts			
Celts and celt fragments	1	4	5
Grooved axe fragment			1
Processing Artifacts			
Hammerstones		6	
Debitage			
Cores		5	
Core fragments		7	
Waste flakes		28	22
Unworked Material			
Nodules and fragments	5	43	5
MISCELLANEOUS			
Processing Artifacts			
Hammerstones			
quartzite			2
Anvil stones			
diorite			2
Metate			
diorite			1
Unworked Material			
Fragments			
quartzite	1		1
granite	4 (10)*		2
siltstone	(1)		(2)
diorite	1		
basalt	1 (1)		
limestone	1		
gneiss	1 (3)		
sandy siltstone	10 (4)		

*Numbers in parentheses indicate burned specimens.

Table 4: Lithic Frequency Distribution Within Color Categories

Chert Category Number	Bifaces and Biface Fragments			Retouched Flakes			Utilized Flakes			Utilized Cores and Core Fragments			Waste Flakes		
	13WP13	13WP14	13WP85	13WP13	13WP14	13WP85	13WP13	13WP14	13WP85	13WP13	13WP14	13WP85	13WP13	13WP14	13WP85
1													18	7	5
2	1												21	4	8
3				1			1		1				24	3	24
4	1			1	1			1			1	2	61	15	64
5	1	1	2				1			3			14	4	18
6	1	6	1							1			11	8	13
7					1		2						12	6	4
8													2	1	2
9													1		
10		1	2	1	2	2	2	3	3				81	59	64
11	1			1				1					26	7	4
12			1	2	2			3		1			12	23	27
13								1					6	9	5
14	1		1	3					1				18	35	22
15		1	2			1							8	6	15
16		1	1	1	3		1	1					4	4	5
17		3											3	3	13
18													7		
19													10	2	
20							1						5		
21			2		1	1			1				1	6	2
22	1												2	3	
23													1		1
24													1	4	
25				1									1		3

Table 4: Lithic Frequency Distribution Within Color Categories (cont'd)

Chert Category Number	Cores			Core Fragments			Retouched Cores & Core Frags.			Preforms			Unworked Fragments		
	13WP13	13WP14	13WP85	13WP13	13WP14	13WP85	13WP13	13WP14	13WP85	13WP13	13WP14	13WP85	13WP13	13WP14	13WP85
1															
2				4	1	1									
3				7	1	1									
4		1		3	2			2							
5		5	4	21	11	3									
6				8	1	5									
7				11	5	2									
8				1	7										
9				1											
10				2											
11				29	3	11									
12				7	2										
13		1		14	5										
14				5	3	6									
15		1		1	6	7					1				
16		2		5	1	1									
17	1			1	3										
18			3	2	6	3		1							
19				1											
20				1	1	1									
21	1		7	4	3										
22		1		8	5	4									
23				1											
24					1										
25						3									

Source: Author's analysis

Due to the lack of a comparative collection of cherts with geologic provenience, the sources of these cherts must be speculative.

Descriptions in the geologic literature are not adequate to assign cherts from the prehistoric sites directly to their sources, be they bedrock, glacial drift or alluvium. However, the cherts from measured stratigraphic sections in the geologic literature can be systematically collected and a comparative collection thus be built. To increase the value of such a comparative collection, duplicate chert specimens can be heat-treated to reproduce changes in color and/or structure analogous to those induced prehistorically.

This proposed stratigraphic comparative collection, would provide a basis for the archaeological description, e.g., structure, fracturing characteristics, surface textures, color, cortex type, fossil content, etc. of geologic units and would necessarily lead to more systematic descriptions of chert which would elucidate cultural patterns, e.g., trade networks and resource utilization.

CERAMICS

One minute piece of amorphous grit-tempered pottery was recovered from 13WP13. This pottery could be tentatively assigned to the Middle Woodland period, ca. 250 B.C.-500 A.D. (White 1968:Fig.3).

Discussion

The three prehistoric sites offer evidence for various activities which have taken place during certain periods in the past. A number of functions are suggested by the artifactual remains and features encountered (Table 5).

Table 5: Interpretation of Evidence from Prehistoric Sites

Evidence	Interpretation(s)
Discontinuous post molds	Temporary shelters, e.g., lean-to
Fire hearths, burned rock, and charcoal areas	Food processing, warmth
Projectile points (also used as knives) bifaces	Procurement of game, processing of game.
Scrapers, utilized flakes and cores	Skinning hide preparation blade manufacture
Metate (grinding slab)	Vegetable processing
Hammerstones and debitage	Chert processing

Since the cultural chronology suggested is Woodland, house structures and storage pits would certainly be present if the sites were permanent villages. The sites probably represent temporary occupations established for the extraction and processing (exploitation) of natural resources. The main occupation sites (permanent or semi-permanent villages) are probably located elsewhere, undoubtedly nearby. Recent surveys in the area conducted by Anton Till, Division of Historic Preservation may supply the data necessary to interpret this settlement pattern more completely. The lack of pottery is further suggestive of temporary occupations at the sites. The artifact assemblages must be studied in light of other nearby Woodland sites to more fully interpret both settlement and exploitative patterns in this part of the Des Moines River Valley.

THE HISTORIC SITES 13WP22 AND 13WP25

Historical Background

Owing to the geographically restricted nature of this report, a detailed historical overview of Wapello County will not be presented here. The reader is referred to Biggs 1865 and Boyd 1867 for sketches of the early settlement; and the county histories of Western Historical Company 1878, Evans 1901, and Waterman 1914 for a more general presentation. Waterman 1914 contains the most comprehensive and detailed historical account of Wapello County. A brief summary of the history of settlement as pertains to the project area is given below as a means of introduction.

When the title to land belonging to the Sac and Fox Indians passed by cession into possession of the United States Government on May 1, 1843, the settlement commenced of what would become Wapello County (Andreas, 1875:364) Immediately population centers grew at Ottumwa, Agency City, Eddyville and Dahlonega.

The town of Chillicothe was platted in 1849 by A. J. Wicker who had originally located near the mouth of Avery Creek in February, 1845 (Western Historical Company, 1878:537). In the period between 1845 and 1849, settlers had been moving into the area surrounding Chillicothe. Indeed, the lands on which 13WP22 and 13WP25 are located were both entered from the U. S. Government in 1848. The original government land plat is shown in Fig. 11. Following is a history of the land tenure of site 13WP22. Specific information regarding land owners is given as may be useful for reviewing the archaeological record.

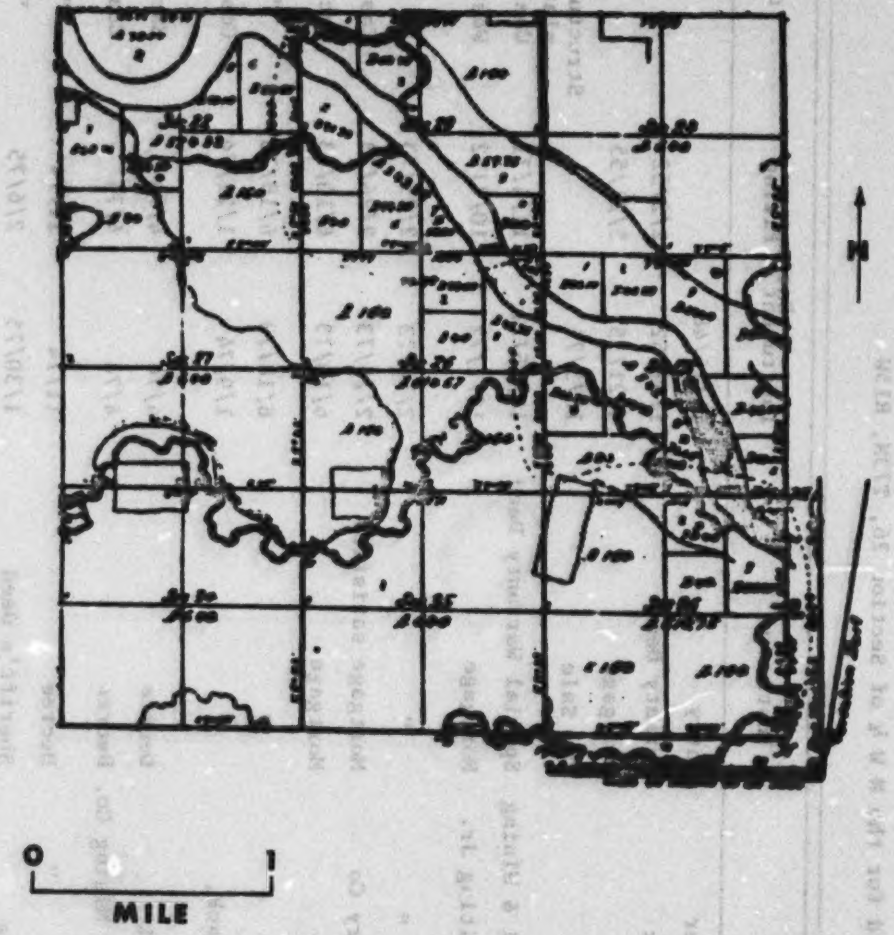

Figure 11. Government Land Office Plat of the southeast portion of Township 73 North, Range 15 West. U. S. Government Land Survey Office, 1847 ms.

Table 6 : Transfer of Land Record for the N W ¼ of Section 26, T73N, R15W

Grantor	Grantee	Instrument	Dates Instrument	Dates Filing	Comment
U. S. Government	N. Dofflemeyer	Entry	12/16/48		
N. Dofflemeyer	J. G. Haycock	Waranty Deed	1/31/52	2/2/52	
J. G. Haycock	same elder	Mortgage	5/21/55	5/21/55	
J. G. Heacock (by treasurer)	A. G. Harrow	Tax Sale	10/5/71		Structure located on Warner (1870) plat map of Wapello County.
W. M. King	National Coal & Mining Co.	Special Warranty Deed	10/25/71	11/4/71	Coal rights-Western 60 acres
National Coal & Mining Co.	Joseph H. Whiting Jr.	Mortgage	10/7/72	10/7/72	Western 60 acres
"	" "	"	2/14/73	2/25/73	" " "
J. G. Heacock	Wm. Jackaberry Co	Mortgage satisfied	2/25/73	2/26/73	East 91 rds. of South 40 rds.
J. G. Heacock & J. M. Hull	J. M. Shelby	Mortgage	6/10/73	6/10/73	Except 40 acres
"	"	"	6/18/73	6/18/73	"
National Coal & Mining Co.	Iowa Nat'l Bank, Ottumwa	"	1/9/74	1/21/74	Coal rights as above
James Shelby	J. G. Heacock	Decree	4/74	4/74	Except S E ¼ of N W ¼
Iowa Nat'l Bank Ottumwa	Nat'l Coal & Mining Co.	Decree	4/74	4/74	Coal rights as above
John Whitney	" " "	Decree	11/74	11/74	" " " "
T. A. Spillman (sheriff)	J. H. Whiting (trustee)	Sheriff's Deed	1/30/75	2/6/75	" " " "
J. G. & S. P. Heacock	Benjamin Haynes	Mortgage	7/22/75	7/22/75	South 40 rds. of East 91 rds. of S ½ of N.W.¼
J. G. Heacock	H. B. Heacock	Mortgage	3/18/76	6/1/76	W½ NW¼ & NE¼ NW¼
Charles Blake	J. G. Heacock	Foreclosure	8/76	8/76	" " " "

Table 6 : Transfer of Land Record for the N W ¼ of Section 26, T73N, R15W (continued)

Grantor	Grantee	Instrument	Dates		Comment
			Instrument	Filing	
T. A. Spillman (Sheriff)	Henry B. Heacock	Sheriff's Deed	10/30/77	10.30/77	W½ NW¼ & NE¼ NW¼
Treasurer	Henry B. Heacock	Treasurer's Deed	4/16/78	4/16/78	N½ NW¼
H. B. Heacock	John A. Brown	Mortgage	3/4/78	4/15/78	W½ NW¼ & NE¼ NW¼
George G. Heacock	H. B. Heacock	Mortgage	3/1/79	3/4/79	Portion of NW¼
H. B. Heacock	The Public	Auction	3/24/79	10/30/79	Fraudulently paid mortgage
H. B. Heacock	Lawrence Guggerty	Warranty Deed	4/7/85	4/18/85	
In matter of Estate of Lawrence Guggerty			12/18/15	12/18/15	Structure does not appear on Allen (1893) plat map of Wapello County.

Source: Allen 1893, McElroy, Truitt and Truitt, n.d.a: 385-386, Warner 1870 and author's research.

Transfer of land records are listed in Table 6 . The most prominent figure involved in the land transactions is John G. Heacock. He came to Iowa in 1852 from Ohio, secured the title to the NW¼ of Section 26 (T73N, R15W) and commenced farming operations. By 1856 Heacock was engaged in milling operations. The citation for Heacock in the 1856 Census (Iowa Census Board 1856 ms; Wapello County: 731-732) gives a picture of his individual estate:

> 116 acres (a) owned, produced 1 ton hay; spring wheat 5a - 5 bu.; winter wheat 5a - 15 bu.; oats 5a - 300 bu.; corn 40 a - 2600 bu.; potatoes 1a -60 bu.; sold 15 hogs - $120; sold 5 cattle - $55; made 100 lb. butter; made 27 lb. wool.

Further notice is made concerning Heacock's profession as a farmer and miller. Waterman (1914, vol. 1:353) notes that by 1865 Chillicothe had a grist mill owned and operated by J. G. and S. P. Heacock which was capable of turning out 300 bushels a day.

The capital which Heacock enjoyed as a result of his farming and milling enterprises was considerable. The figures are shown below:

Table 7: The Capital of J. G. Heacock

Date	Valuation		Source
	Land	Personal Property	
1857	4128	796	Wapello Co. Assessor 1857 ms
1860	4080	1120	U. S. Bureau of the Census 1860
1870	20000	2149	U. S. Bureau of the Census 1870

The census records also indicate that in 1860, Heacock had a wife and five children (Census Bureau 1860:602).

13WP25

The title transfer record for the Southwest quarter of Section 26, T73N, R15W is presented in Table 8.

The person who appears to be significant with regard to 13WP25 is D. S. McQuiston. All that is known from available archival sources about Davis S. McQuiston is the description in the 1870 Federal Census (U. S. Census Bureau 1870:39) which lists him as: 35 years of age, born in Pennsylvania, married to a woman born in Iowa, father of three children born in Iowa. One woman (possibly mother-in-law) is also listed as being in the household. The real estate owned by McQuiston is valued at $6000 and his personal estate at $819.

McQuiston appears to have been involved in some irregular deed transaction with the former title holder of the land, Joshua Lowmiller (see Table 8). The entire transaction scheme is not entirely clear, but McQuiston lost the title to the land after being the holder for two years. According to Loren Horton (personal communication), the fact that McQuiston took out a mortgage on the land in 1869 is a positive sign that he was planning to build a house on it. The fact that a structure is shown by Warner (1870) (Fig. 12) on the land of D. S. McQuiston is further evidence that the house is McQuiston's and that it was probably built after March 1, 1869.

Table 8 : Transfer of Land Record for the S W ¼ of Section 26, T73N, R15W

Grantor	Grantee	Instrument	Dates Instrument	Dates Filing	Comment
U. S. Government	Hiram Webb	Entry	12/20/48		
Hiram Webb	Sam Webb	Warranty Deed	3/24/51	3/5/54	
Sam Webb	Joshua Lowmiller	Warranty Deed	11/1/55	11/3/55	
Joshua Lowmiller	D. S. McQuinston	Warranty Deed	2/11/69	4/30/69	
D. S. McQuinston	J. Lowmiller	Mortgage	3/1/69	4/30/69	
J. Lowmiller	D. S. McQuimston	Returned execution (Court Sale)	5/14/71	8/15/71	
J. Lowmiller	D. S. McQuimston	Decree		6/16/71	Structure present on Warner (1870) plat map of Wapello County
Sheriff	J. Lowmiller	Sheriff's Deed	8/15/71	8/15/71	
J. Lowmiller	P. Omalia	Warranty Deed	1/17/77	2/2/77	
P. Omalia	Joseph Jewitt	Mortgage	11/13/84	11/18/84	
P. Omalia	Bridget Molony	Mortgage	9/29/86	10/14/87	
P. Omalley	J. H. Waddington	Mortgage	2/7/87	2/7/87	Structure not present on Allen (1893) plat map of Wapello County.
J. Jewitt	P. Omalley	Extension	10/13/96	3/16/97	
P. Omalley	J. J. Omalley	will			

Source: Allen 1893; McElroy, Truitt and Truitt n.d.a: 385-386; Warner 1870; and author's analysis.

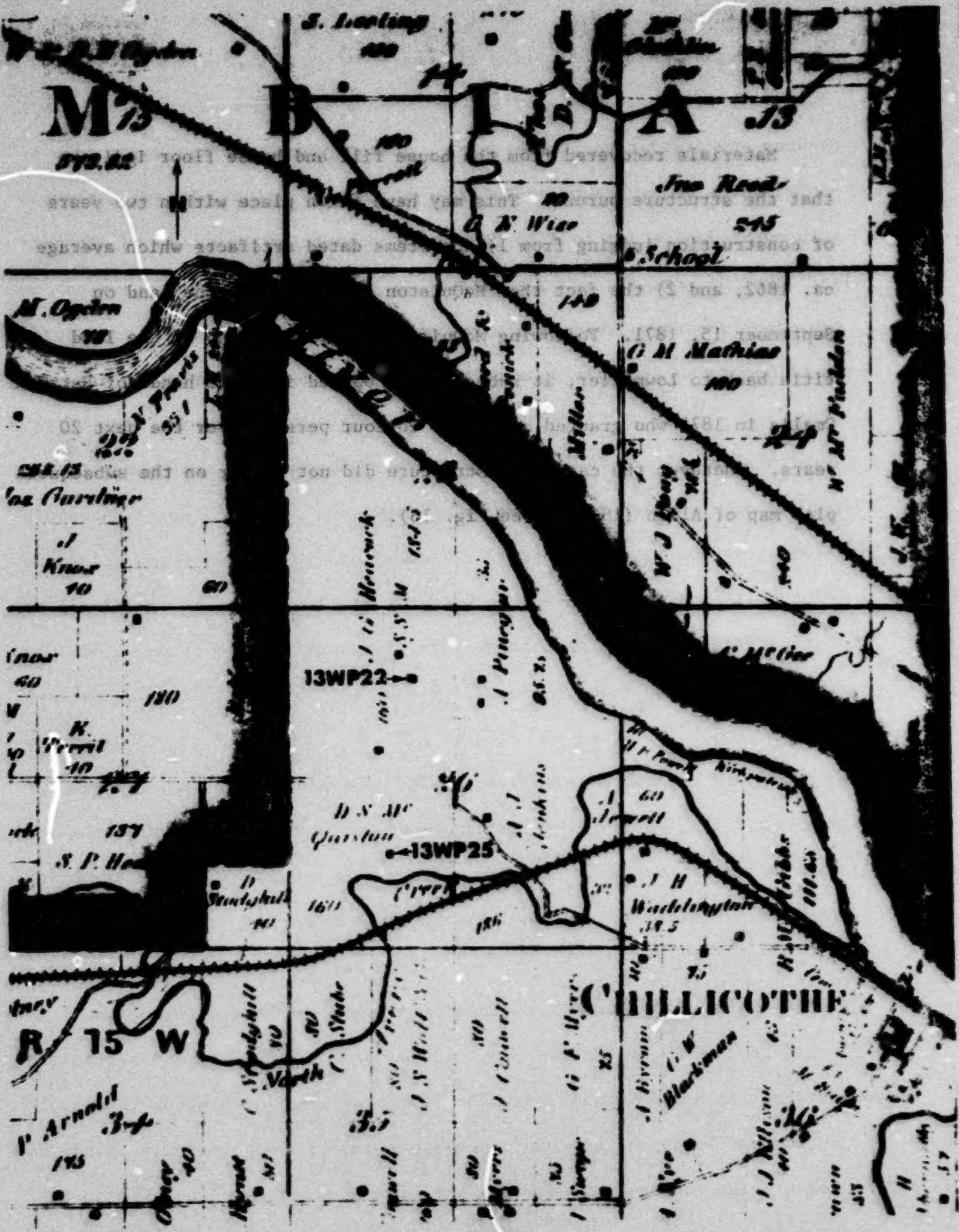

Figure 12. Southeast portion of Township 73 North, Range 15 West in 1870 showing sites 13WP22 and 13WP25 Warner (1870).

Materials recovered from the house fill and house floor indicate that the structure burned. This may have taken place within two years of construction judging from 1) the items dated artifacts which average ca. 1862, and 2) the fact that McQuiston lost title to the land on September 15, 1871. Following McQuiston's relinquishing of the land title back to Lowmiller, it subsequently passed into the hands of Patrick Omalia in 1877 who granted mortgages to four persons over the next 20 years. Whatever the case, the structure did not appear on the subsequent plat map of Allen (1893) (See Fig. 13).

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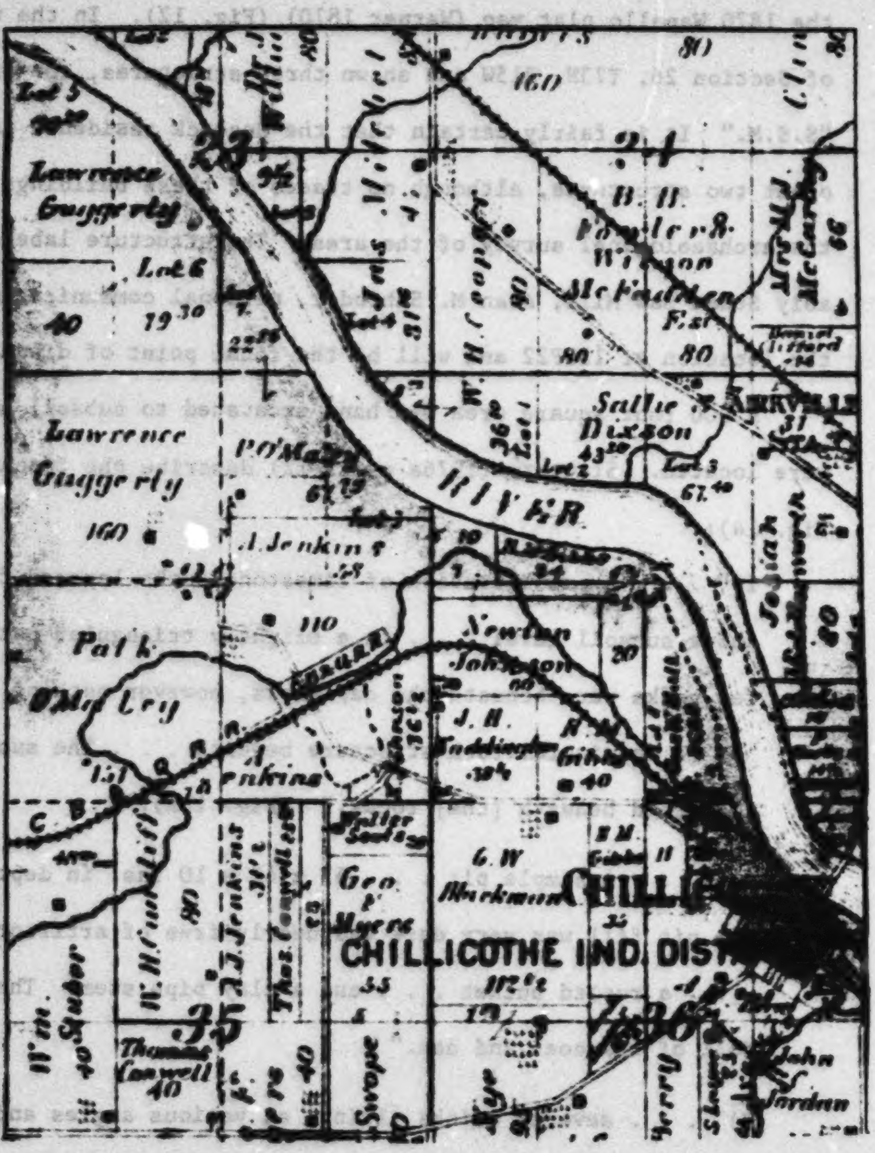


Figure 13. Southeast Portion of Township 73 North, Range 15 West in 1893. Allen (1893).

Site Plans

13WP22

The first evidence of occupation on the Heacock property is found on the 1870 Wapello plat map (Warner 1870) (Fig. 12). In the northwest quarter of Section 26, T73N, R15W are shown three structures, one of which is labeled "S.S.M." It is fairly certain that the Heacock residence is one of the other two structures, although no traces of these buildings were found on the archaeological survey of the area. The structure labeled S.S.M (probably Steam Saw Mill, Alan M. Schroder, personal communication) appears in the location of 13WP22 and will be the focal point of discussion following:

A 900 foot square area was hand excavated to subsoil and three features were located. Slattery (1976a ms:11-12) describe the features as follows Fig. 14):

> 1)" . . . A concentration of limestone rocks layered flat some 10 in. above subsoil level . . . in a slightly triangular pattern . . . A few rocks were beneath the cap rocks, however nothing could be seen of [a meaningful]rock structure beneath . . . The subsoil was not disturbed beneath [the] rocks." (Fig. 15A).
>
> 2)" . . . A simple pit . . . 51 x 41 x 10 ins. in depth (below subsoil). The pit fill was very dark and nearly free of artifacts except for . . . . a rusted bucket . . . and a clay pipe stem. The pit fill was full of charcoal and ash."
>
> 3)" . . . several bricks [lying] at various angles and an ash layer together with a few stones (limestone). All of this some 10 in. above subsoil level. After excavation of these items no evidence of anything further was noted."

An area north of the Features 1 and 2 contained a heavy scattering of cultural debris. This area was partially within the area of excavation and partially without (Fig. 14).

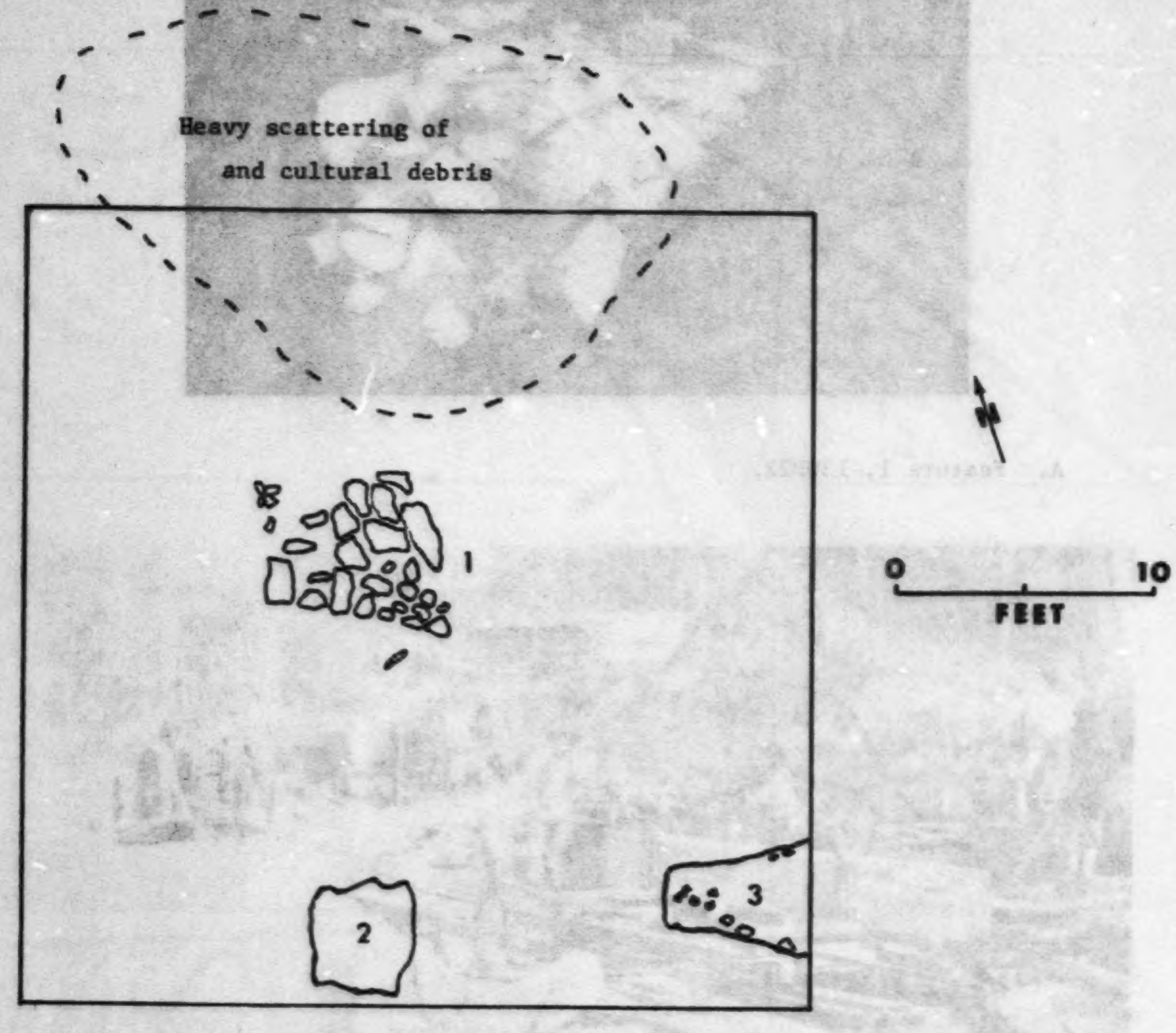
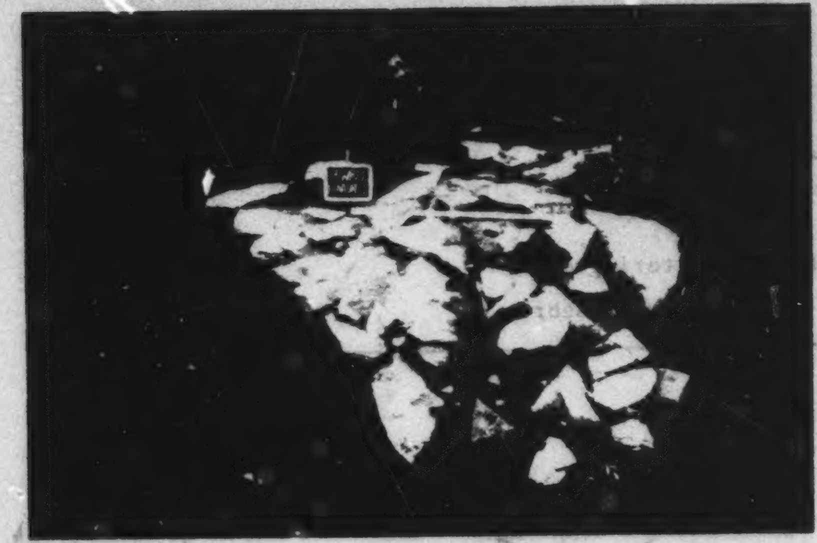
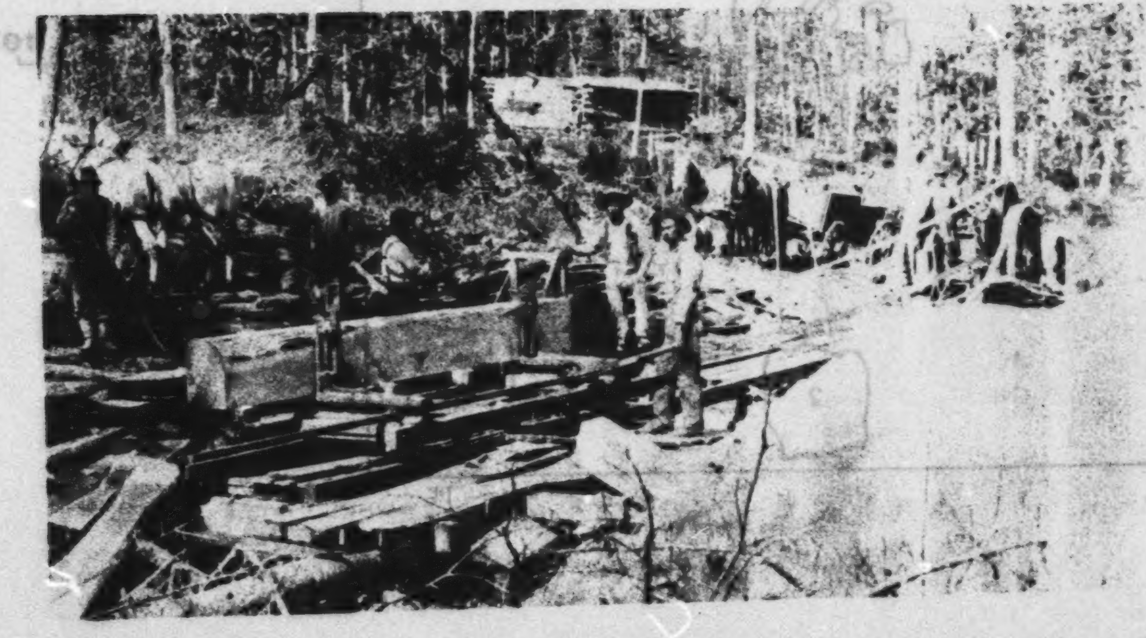


Figure 14. Site Plan, 13WP22, showing Features 1-3. After Slattery (1976c ms.).



A. Feature 1, 13WP22.



B. Portable steam saw mill near Iowa City, ca. 1893. Courtesy of Iowa State Historical Department, Division of the State Historical Society, photograph collection.

Figure 15. 13WP22, Feature 1 and a portable steam saw mill near Iowa City, Iowa.

Schroder (personal communication) of the State Historical Society suggested the "S.S.M." might refer to a steam-saw mill of a portable type used in the late Nineteenth century. A saw mill of this type is reproduced in Fig. 15B. In this context, Schroder suggested that feature 1 could represent a platform for the boiler, motor or rigging, Feature 2 could either be a pit for reducing wood to charcoal for more economy in buring in the boiler or for disposing of wood shavings, and the scattering of artifacts north of the Features 1 and 2 may be the remains of a small shack or building adjoining the mill. The shack possibility shall remain speculative as the front end loader accidentally dug too deeply in that area and removed a swath of soil adjacent to the excavated area (Slattery, personal communication). Such a shack was frequently associated with saw mills of this type and is shown in the background of Fig. 15.

13WP25

Removal of the plowzone from historic site 13WP25 revealed three features related to an historic farmstead: the cellar of a house, a well and a refuse pit (Fig. 16).

THE HOUSE

Slattery (1976a ms) described the house as completely collapsed with a few limestone rocks strewn unpatterned throughout the site. The fill within the house was a heavy mixture of limestone rock, broken brick, and artifacturl material (described subsequently in this report). The subsurface floor of the house basement was located four feet below present ground surface and followed until the side walls were located and defined as being 12 x 14 ft. in dimensions. A stone apron and entryway 3 ft. wide was also delineated. There was no indication that the limits of the basement excavation represented the entire dimensions of the superstructure.

Within the house fill were found charred wooden beams, as well as burned china and melted glass, indicating that a fire destroyed the wooden

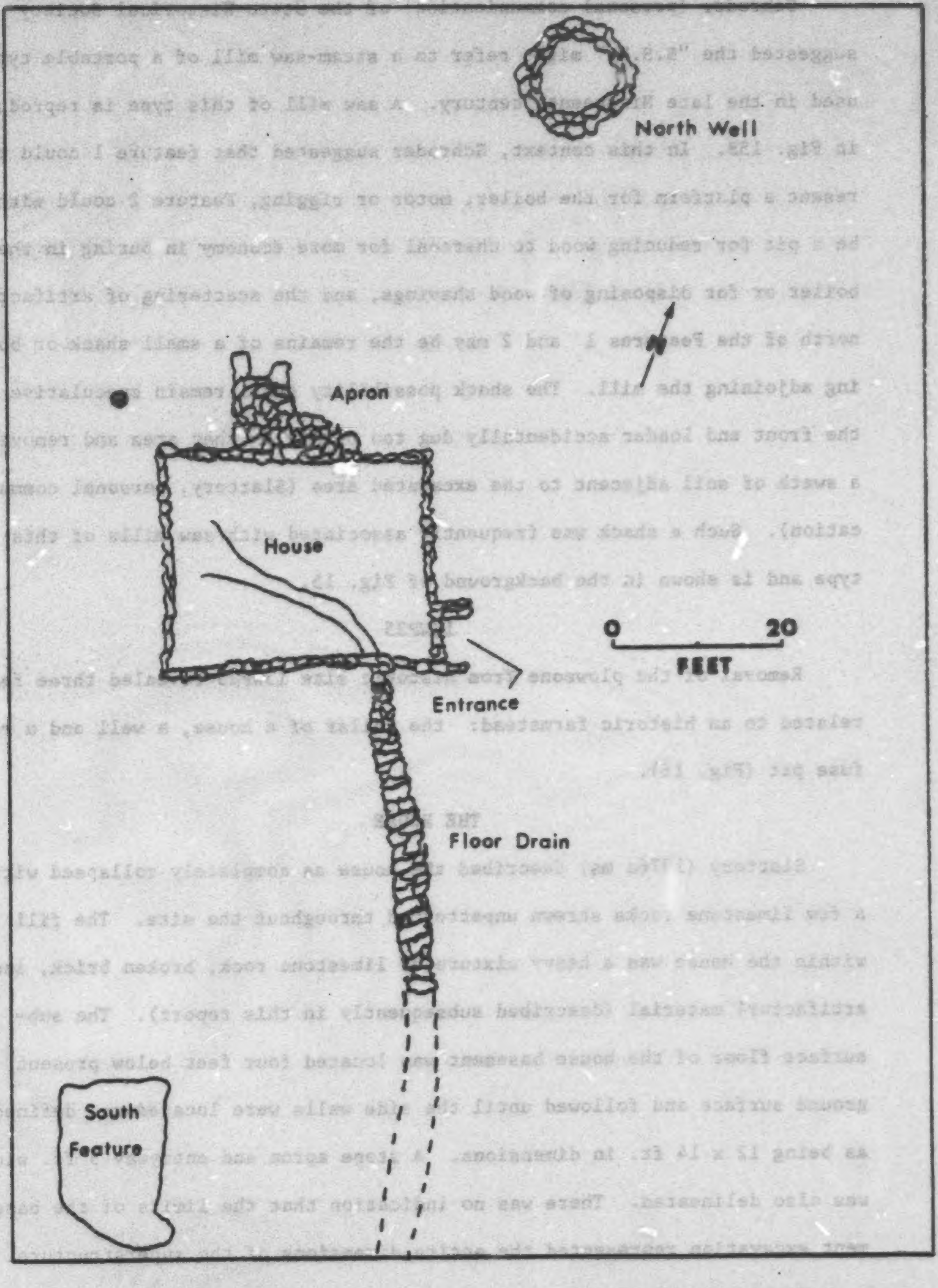


Figure 16. Site Plan, 13WP25. After Slattery (1976c ms.).

structure above ground. No patterning in the fallen beams could be ascertained. The house and the well were linked temporally by the discovery of one piece of china from each of the features which, when joined, comprised a single sherd.

The limestone used in construction is certainly from the local St. Louis formation which Leonard (1902) recognized as a geologically suitable building stone exposed and quarried at several places near Chillicothe. The limestone had been cut, dressed and laid in a Regular Ashlar Bond construction (Horton 1972 ms: 4 and personal communication) (Fig. 17a).

THE NORTH WELL

This feature located about 25 ft. north of the house contained a fill of broken limestone and brick fragments (Fig. 16). At a depth of 5 ft. below present ground surface a limestone circular wall of 5 ft. 2 in. inside diameter which extended down 9 ft. further. Within this feature was recovered a complete horse skeleton and a few artifacts, mainly nails. There was evidence that wooden framing or shoring once existed above the limestone circular wall.

THE SOUTH FEATURE

A refuse pit was located about 30 ft. south of the house. Much artifactual material was recovered from this feature. The irregular shape of this feature is displayed in Fig. 16. Slattery (1976a ms:8) describes a stratigraphic profile of this feature as: cultural within the top 18 ins., a steril layer, and a darker soil layer beneath which a "floor" of charcoal and ash was present.

THE FLOOR DRAIN

Slattery (1976a ms:4) noted a trench on the subsurface floor of the house "8 ins. wide and 3 ins. deep angling across the floor [and] ending near the SE corner of the basement." Subsequent excavation showed this

A. General view of house during excavation.

B. View of the base of the floor drain.

Figure 17. Views of the house and floor drain at 13WP25.

trench extending through the basement wall and into "a long...underground, rock covered, rock sided trench... which extended 37 ft. to a lower exit elevation (Slattery 1976a ms:6). Stone construction of this trench is shown in Fig. 17B. The floor drain was built with a great deal of care. Loren Horton (personal communication) relates that very rarely in 19th century Iowa did houses have a stone floor drain. He knew of only one other house (the Antoine LeClaire House in Davenport) with such a feature. This may be a custom originally from the British Isles, i.e., an anachronism, as such construction appears to be Medieval in style.

Guilland (1971:9) posits a reason for construction of this floor drain: "Some New Jersey and Pennsylvania settlers dug basements which were used for kitchens in the warmer months. These basement kitchens often had running water from springs under the house..." It is noteworthy that McQuiston, the builder of the house, is from Pennsylvania.

Also Guilland (1971:7) points out that basements of houses were used in the warmer months for storage of perishable items such as butter, milk and meat. This might account for the stoneware recovered from the basement floor (see below). If there was a spring in the basement, cooling of the perishable items would have been facilitated.

Material Culture Inventory

The artifactual material recovered from both the Phase II and Phase III work is included in the descriptions below. For additional illustrations of china from the sites see Slattery and Tandarich (1975:43). Much of the metal recovered was not identifiable. This compliation represents an attempt to provide future researchers with a listing of items associated with these particular site types, the first known to have been excavated in Iowa.

CLAY BODY MATERIALS

STONEWARE

Reynolds (1969 ms) and Schulte (1974 ms) have made the first attempts to analyze stoneware from local kilns in Iowa. Their categorizations of vessel forms are useful for describing the stoneware from both 13WP22 and 13WP25. Reynolds designed rim forms categories for analytic use. The distinctions he made between his "folded" and "reserve" rim are not clear to this writer from his profile drawings alone. Therefore, a rim analysis is not presented in this report.

The basic vessel forms and probable number of different vessels represented at 13WP22 and 13WP25 are presented below.

Table 9: Stoneware Form Summary

Form Type	Number Definite		Questionable		Form Type Illustration
	13WP22	13WP25	13WP22	13WP25	
Simple Bowl	2	8	2	1	Fig. 18D, 18J
Milk Bowl	9	5	1	0	Fig. 18E
Crock (all types)	7	4	1	0	Fig. 18F 18J
Jar (all types)	3	2	1	0	Fig. 18B, 18C
Jug	0	3	0	1	Fig. 18A
Cover	0	1	0	0	Fig. 18J
Holder	0	2	0	0	Fig. 18K

Source: Reynolds 1969 ms; Schulte 1974 ms, and author's analysis.

More detailed descriptions of the stoneware from both sites are presented in Tables 10 and 11. The stoneware sample being small and fragmentary made

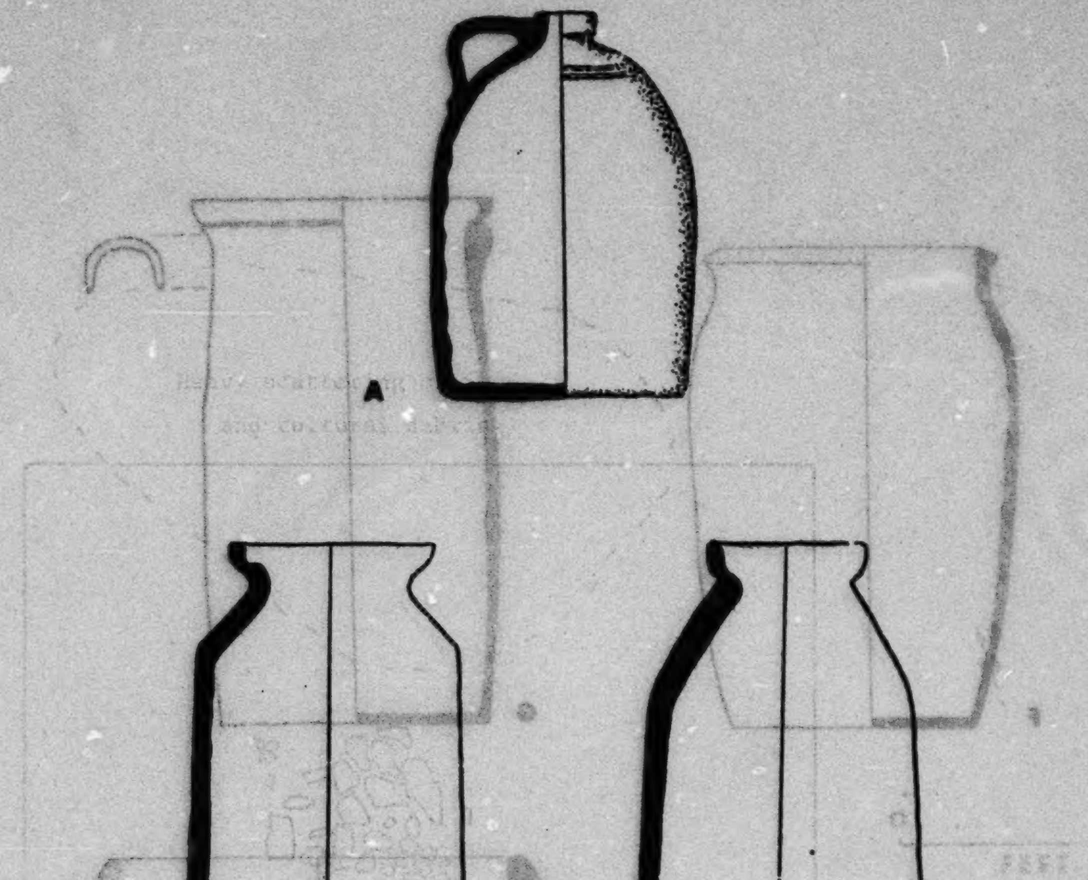


Figure 18. Stoneware vessel forms at 13WP22 and 13WP25. Not to scale. A. Jug (after Schulte 1974 ms., Fig. 31); B, Angle Shoulder Jar (after Reynolds 1969 ms., Fig. 48); C, Rounded Shoulder Jar (after Reynolds 1969 ms., Fig. 49); D, Simple Bowl (after Reynolds 1969 ms.. Fig. 39): E, Milk Bowl (after Schulte 1974 ms., Fig. 12A).

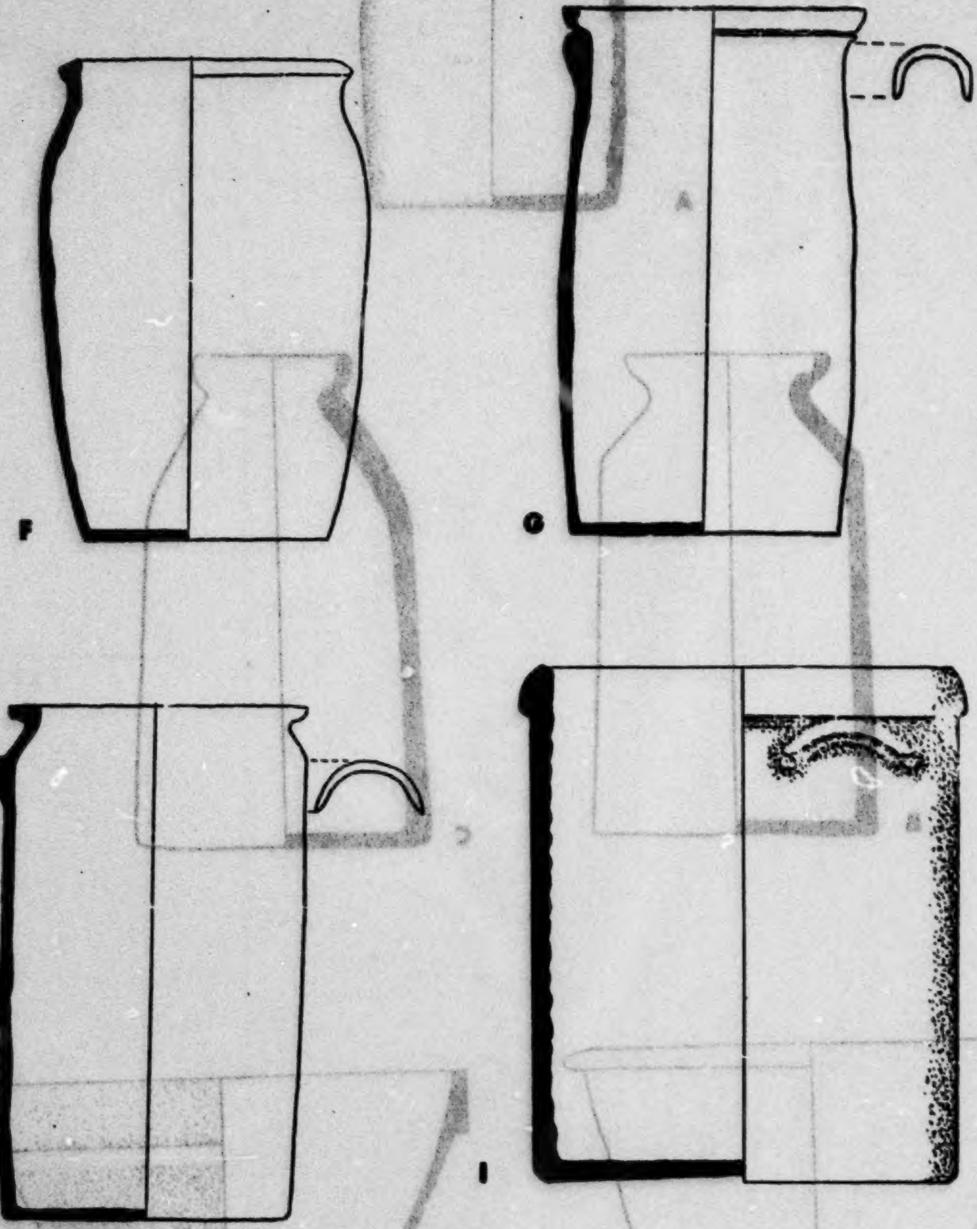


Figure 18 (continued). F, Rounded-Shoulder Crock (after Reynolds 1969 ms., Fig. 45); G, Churn (after Reynolds 1969 ms., Fig. 52); H, Straight-sided Angle-Shoulder Crock (after Reynolds 1969 ms., Fig. 43); I, Straight-sided Crock (after Schulte 1974 ms., Fig. 14).

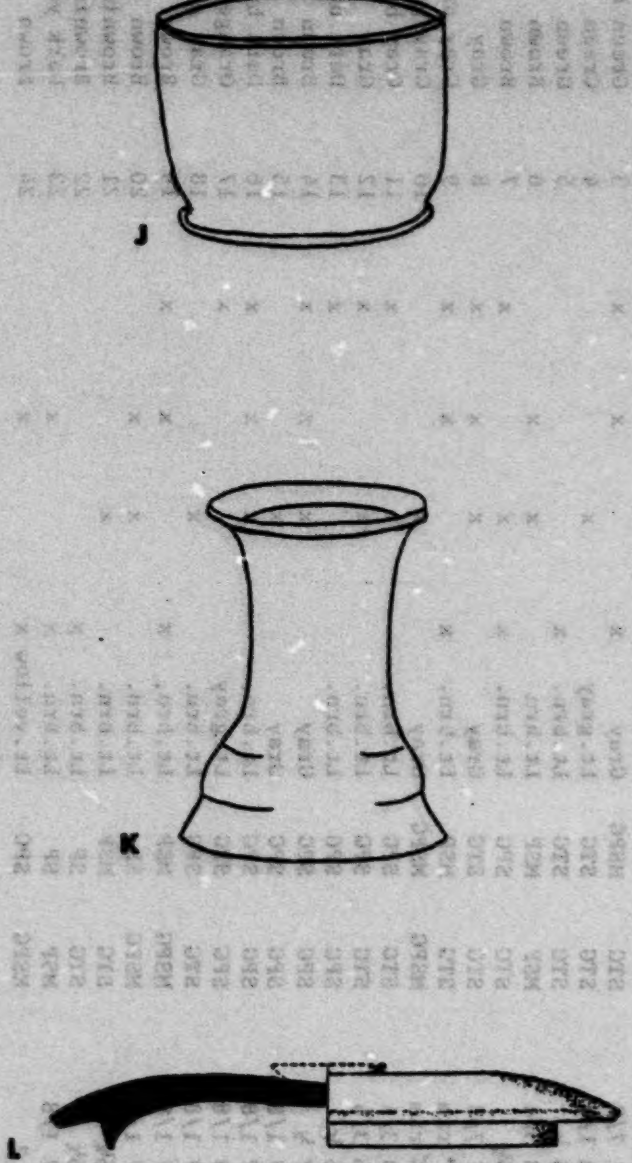


Figure 18 (continued). J, Bowl or Cup (after Rice and Stoudt 1929, No. 44); K, Holder (after Rice and Stoudt 1929, No. 141); L, Cover for Crock and/or Churn (after Schulte 1974 ms., Fig. 29D).

Table 10: Analysis of Stoneware From 13WP22

umber of ragments[a]	Form	Vessel Dimensions (in inches) Rim	Base	Total Height[b]	Surface Treatment[c] Extnl.	Intnl.	Paste Color[d]	Finger Ridges	Striations Intnl.	Extnl.	Rim Tooling	Reference Number	External Color[e]
9	Crock[f]	3/4	8 3/4		STG	MSPG	Lt.brn.	x		x	x	1	Lt. yellow brn mottled
12	Milk Bowl	10¼	< rim		MSPG	MSPG	Lt.brn.		x	x		2	Brown
7	Crock	11	7 7/8		STG	MSPG	Gray	x		x	x	3	Green & brown mottled
5	Jar ?	?	3 1/8		STG	STG	Lt.gray		x			4	Cream
4	Crock	6¼	5 ½		STG	STG	Lt.brn.	x				5	Green
7	Milk Bowl	10¼	8 3/4		MSP	MSP	Lt.brn		x	x		6	Brown
11	Jar	4 3/8	5½		STG	SPG	Lt.brn.	x	x		x	7	Brown
8	Crock?	8 3/4	7 7/8		STG	STG	Gray		x	x	x	8	Gray
11	Jar	?	> rim		STG	MSP	Lt.brn.	x		x	x	9	Gray green[g]
5	Bowl?	8 3/4	< rim		MSPG	MSPG	Gray		x			10	Gray green
7	Crock	8 3/4	8 3/4		STG	SPG	Lt.brn.		x		x	11	Gray brown mottled
7	Bowl?	8 3/4	6 3/4		STG	SPG	Lt.brn.		x		x	12	Gray
7	Crock or jar	?	6 ¼		SPG	SPG	Lt.brn.				x	13	Dark brown
9	Jar	7 1/8	7 ½		SPG	SPG	Gray		x	x	x	14	Brown
12	Milk Bowl	10¼	7 1/8		SPG	SPG	Gray		x			15	Brown
9	Milk Bowl	10¼	7 1/8		SPG	SPG	Lt.brn.		x	x	x	16	Dark brown
5	Milk Bowl	?	7 1/8		SPG	SPG	Lt.gray				x	17	Orange brown
4	Milk Bowl	10¼	7 1/8		STG	SPG	Lt.brn.		x			18	Gray green
3	Milk Bowl	10¼	7 1/8		MSPG	MSP	Lt.brn.	x		x	x	19	Brown
4	Milk Bowl	10¼	7 1/8		MSPG	SP	Lt.brn.		x	x		20	Brown (below rim)
7	Bowl	8 3/4	6¼		STG	MSP	Lt.brn.		x			21	Brownish green
4	Crock	?	6¼		STG	SP	Lt.brn.	x				22	Brownish green
3	Milk Bown	?	7 1/8		MSP	SP	Lt.brn.	x		x		23	Dark yellow brown
3	Crock	7 7/8	?		MSPG	SPG	Lt.yellow brn	x		x		24	Brown

a Abbreviation: R - partially or completely restored
b Vessel height was indeterminable in all cases for material from 13WP22
c Abbreviations: STG-salt glaze; SPG-slip glaze; MSPG-matte slip glaze; MSP-matte slip unglazed
d Color names based on Munsell Soil Color Chart, Hue 10 YR
e Not standard colors; some colors vary over surface of vessel
f Impressed mark of Mayer & Br. present see text
g Evidence of a cobalt blue decoration, design not discriminable

Source: Author's analysis

Table 11 : Analysis of Stoneware from 13WP25

umber of[a]		Vessel Dimensions (in inches)		Total	Surface Treatment[b]		Paste[c]	Finger	Striations		Rim	Ref.	Prove-[d]	External[e]
ragments	Form	Rim	Base	Height	Extnl.	Intnl.	Color	Ridges	Intnl.	Extnl.	Tooling	No.	nience	Color
1	Bowl	9 3/4		5 3/8	SPG	MSP	Gray	x			x	1	SF	Brown
1	Crock	7 7/8	?	?	SPG	MSP	Gray			x	x	2	SF	Gray
1	Bowl	7 7/8			SPG	SPG	L.brn.	x			x	3	H	Brown
	Bowl	8 3/4			SPG	MSP	Gray		x	x	x	4	SF	Green
R	Milk Bowl	10 ¼		4½	SPG	SPG	L.brn.				x	5	H,SF	Dusky red
R	Milk Bowl	10 ¼	6 3/4	4 3/4	MSP	MSP	L.brn.			x	x	6	HF	Reddish brown
	Milk Bowl	10 1/8	6 3/4	4¼	SPG	SPG	L.brn.		x	x	x	7	HF	Yellow greenish brn.
R	Jug	1 ¼	7 1/8	10	MSP	MSP	L.brn.	x	x		x	8	HF	Lt.orange brn.
R	Jug	1	7 7/8	8½	SPG	SPG	L.brn.	x				9	HF	Deep brn.
R	Jug?	?	7	?	SPG	SPG	L.gray	x			?	10	HF	Brown
3	Crock[f]	10¼	8 3/4	?	SPG	SPG	Gray			x		11	S,H,SF	Gray green
1	Crock	10¼	?	?	SPG	SPG	L.gray	X		X		12	H	Brown yellow
1	Bowl	?	9 1/16	?	SPG	SPG	L.gray				?	13	H	Orange brown
1	Jar	2 3/4	?	?	SPG	SPG	L.brn.					14	HF	Brown
1	Jar	6¼	?	?	MPS	MPS	Gray	x				15	H	Mottled brown
6	Bowl	8 3/4	6 3/4	?	MSP	SPG	L.brn.			x	x	16	H,SF	Lt.orange
6	Bowl	10¼	7 1/16	?	SPG	MSP	L.brn.			x	x	17	H,SF	Orange brown
3	Crock[g]	7 7/8	?	?	STG	MSP	Gray			x		18	SF	Greenish gray
1	Cover[g]	9 5/8	7 7/8	?	STG	MSP	L.brn.			x		19	SF	Greenish gray
13	Jug	1 1/16	?	?	SPG	SPG	Gray	x			x	20	HF,H	Dark greenish brn.
1	Holder[h]	?	2¼	?	None	None	Gray				?	21	H	Gray
1	Bowl	10¼	rim		SPG	MSP	Gray			x		22	H	Brown
1	Bowl	10¼	rim		SPG	SPG	L.brn.		x	x		23	SF	Gray
9	Milk Bowl[i]	10¼	rim		SPG	SPG	L.brn.				x	24	H,HF,SF	Brown
1	Bowl?[j]	8 3/4	rim	?	SPG	SPG	L.brn.			x		25	H	Brown
2	Milk Bowl	?	5½[j]		MSPG	MSPG	L.brn.				?	26	H	Dark brown
1	Holder	?	2¼	?	MSP	MSP	Gray	x			?	27	H	Brown

a Abbreviation: R-partially or completely restored

b Abbreviations: STG-salt glaze; SPG-slip glaze; MSPG-matte slip glaze; MSP-matte slip unglazed

c Paste color names based on Munsell Soil Color Chart, Hue 10 YR

d Provenience abbreviations: H-house; HF-house floor; SF-south feature; S-surface

e Not standard colors; some colors vary over surface of vessel

f Impressed mark present "DAHLONEGA 5" see text

g Appears to match no. 18 in color and glaze and may have been made expressly for that crock.

h This holder and No. 27 may be similar in form to item no. 141 in Rice and Stoudt (1929:131). (Fig. 18K).

i May be similar in form to no. 44 in Rice and Stoudt (1929:119). Fig. 18J.

j Exhibits a raised foot

Source: Author's analysis

form reconstruction difficult. Reynolds and Schulte's forms in some case do not quite match the forms represented here. This is probably due to the differences in methods of manufacture. In order to more fully analyze the stoneware, the kiln sources should be located and the materials compared. In the 13WP22 stoneware sample an impressed maker's mark was observed which read: AYER & BRO LE I 3 (Fig. 19A). This probably is the mark of Mayer & Bro. Pottery, Eddyville, Iowa. This writer heard from locals in Ottumwa that there was a Mayer family in Eddyville making pottery, but until now there had been no substantiating data to confirm those reports. There is little additional information available on the Mayer pottery kiln. Vivian Jones of Eddyville has a complete stoneware vessel from the Mayer kiln. Unfortunately, this writer was unable to study that specimen or visit the kiln site which Mrs. Jones kindly located at this writer's request. Mrs. Jones reports (personal communication) that the Mayer pottery closed in 1892. The history of a kiln site at Dahlonega, the product of which was found at neighboring site 13WP25, is discussed in Appendix A (Fig. 19B & 19C).

In addition to specific stoneware forms described in Table 11, 112 fragments were recovered from 13WP25 which could not be form linked with specific vessels. The type of fragments and their distribution by provenience is given below:

Table 12: Distribution of Non Form-Linked Stoneware from 13WP25

	Fragment Type			
Provenience	Rim	Body	Base	Handle
House floor	1	6	1	
House		59	11	1
Surface	1		1	
South feature			26	
North well			5	

Source: Author's analysis

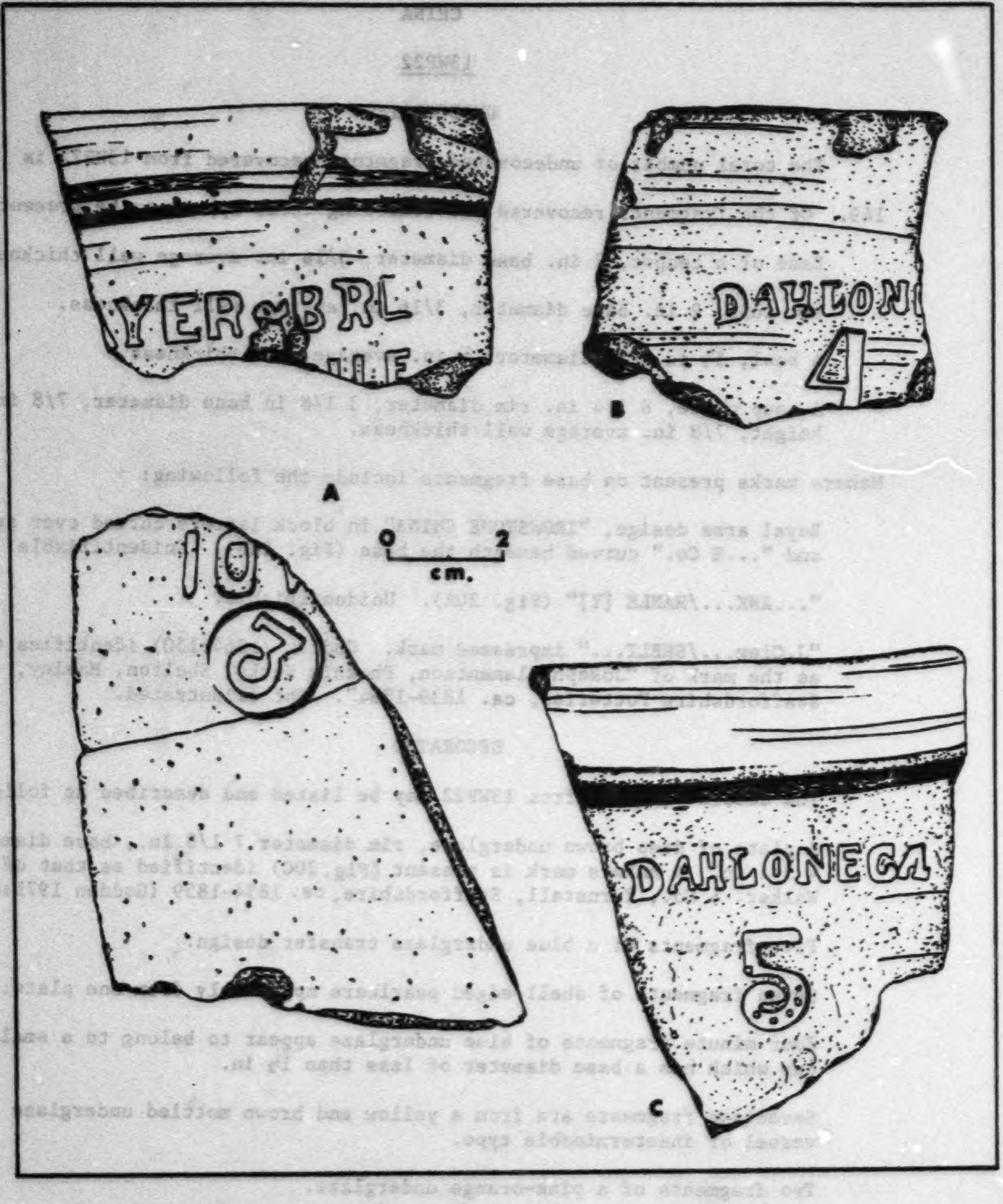


Figure 19. Impressed Maker's Marks on Stoneware. A, Mayer and Brothers, Eddyville, Iowa, from 13WP22; B, Dahlonega Stamp, 13WP107 (see Appendix A); C, Dahlonega Stamp, 13WP25.

CHINA

13WP22

UNDECORATED

The total number of undecorated fragments recovered from 13WP22 is 149. Of the fragments recovered the following items appear to be present:

Base of a teapot, 2 in. base diameter, 3/16 in. average wall thickness.

Two cups, 2 in. base diameter, 3/16 in. average wall thickness.

A bowl, 5½ in. rim diameter, ¼ in. average wall thickness.

A soup plate, 8 3/4 in. rim diameter, 3 1/8 in base diameter, 7/8 in. height, 7/8 in. average wall thickness.

Makers marks present on base fragments include the following:

Royal arms design, "IRONSTONE CHINA" in block letters curved over arms and "...E Co." curved beneath the base (Fig. 20B). Unidentifiable.

"...ANK.../HANLE [Y]" (Fig. 20A). Unidentifiable.

"J.Clem.../SHELT..." impressed mark. Godden (1964:150) identifies this as the mark of "Joseph Clementson, Phoenix Works, Shelton, Hanley, Staffordshire Potteries, ca. 1839-1864". Not illustrated.

DECORATED

The decorated china from 13WP22 may be listed and described as follows:

A plate of deep brown underglaze, rim diameter 7 1/8 in., base diameter 4 3/4 in. A makers mark is present (Fig. 20C) identified as that of Podmore, Walker, & Co., Turnstall, Staffordshire, ca. 1834-1859 (Godden 1971:82).

Five fragments of a blue underglaze transfer design.

Seven fragments of shell-edged pearlware apparently from one plate.

Four minute fragments of blue underglaze appear to belong to a small cup which has a base diameter of less than 1½ in.

Seventeen fragments are from a yellow and brown mottled underglaze vessel of indeterminable type.

Two fragments of a pink-orange underglaze.

Four fratments are deep yellow underglaze.

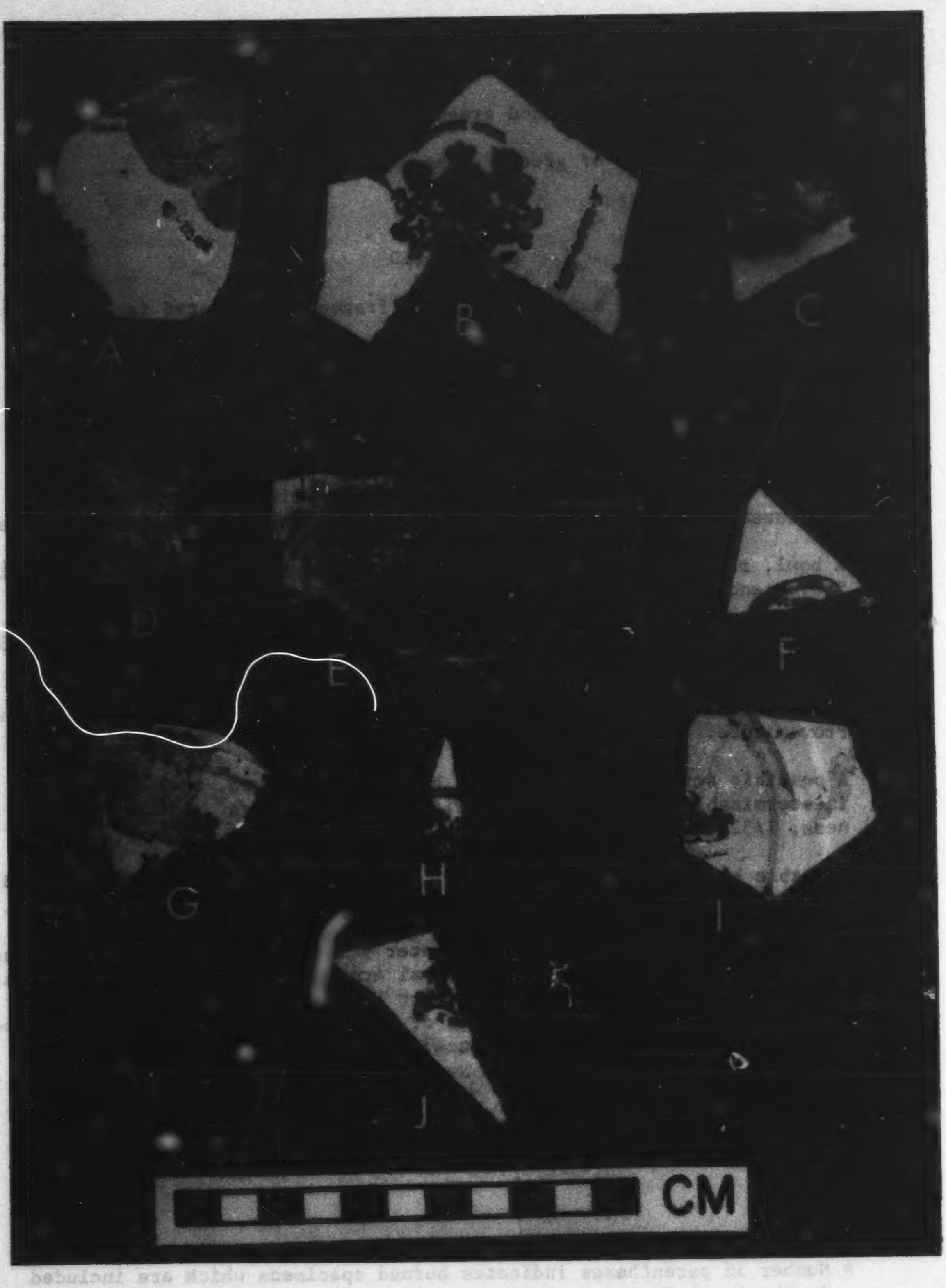


Figure 20. Maker's Marks on China, 13WP22 and 13WP25. A-C, 13WP22; D-J, 13WP25.

One fragment of a purple and green floral painted underglaze.

Three fragments are of green "spongeware."

13WP25

UNDECORATED

The distribution of undecorated china fragments recovered is shown below:

PROVENIENCES

House Floor	House	South Feature	North Well	Total
13(1)*	50 (13)	74(10)	22(1)	159(25)

Undecorated china vessels which were able to be described are listed below:

A bowl, rim diameter 6½ in., height unknown, average body thickness 3/16 in. Provenience: SF and NW.

A bowl, rim diameter 6¼ in., height 1¼ in., average body thickness 4/16 in. Provenience: NW.

A plate, rim diameter 8¼ in., height unknown, average thickness 3/16 in. Provenience: SF.

A possible serving plate, perhaps hexagonal in shape, measurements indeterminable. Embossed with relief bracket design. Average thickness, 7/32 in. Provenience: SF.

Probable bowl, rim diameter 6¼ in., height unknown, average thickness 3/38 in. Provenience: H.

Soup? plate, of ironstone, rim diameter 9 in., height, average thickness ½ in. Incomplete marker's mark showing Royal Arms and part of Ironstone China. Arms design is characteristically post 1837 (Fig. 20E) (Godden 1964: 552), but none of the dictionaries of maker's marks consulted could provide more information. Provenience: NW.

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* Number in parentheses indicates burned specimens which are included in the total fragment count.

Soup? plate of ironstone, rim diameter 9 in. height 1½ in., average thickness 3/8 in. Badly burned in house fire, no maker's mark detectible. Provenience: HF and H.

Possible base of hexagonal shape, dimensions indeterminable, average thickness 3/16 in. Provenience: SF.

Probable base of water pitcher, of hexagonal shape, estimated to be 12" in perimeter. Provenience: SF.

Cup of ironstone, rim diameter 3½ in., height 3 1/16 in., average thickness 14 in. Discoloration has occurred due to house fire. Provenience: HF and H.

The following makers marks were recovered on undecorated china base fragments:

Portion of maker's mark exhibiting a scroll pattern (Fig. 20I). Unidentifiable. Possibly from a bowl. Provenience: NW.

Portion of maker's mark displaying a circular pattern and "CHIN" (Fig. 20H). This mark was unidentifiable. Provenience: H.

DECORATED

Decorated china is represented by the following categories:

Blue shell-edge whiteware (and possibly some pearlware) is represented by twenty rims of varying types (Noel-Hume 1969). Fragment distribution*: 4 (HF); 3 (H), 9 (SF), 3 (NW), 1 (S). (Fig. 21A-21D are examples).

One cup base, blue floral design, base diameter 1½ in. Resembles porcelain in quality although this fragment is not translucent. (HF).

Twenty blue speckled underglaze fragments probably represent one cup, one saucer and one plate. Possible maker's mark "O". Fragment distribution: 2 (HF), 8 (H), 8 (SF) and 2 (NW).

* Abbreviations: HF-house floor, H-housefill, SF-south feature, S-surface, NW-north well.

Eleven blue underglaze fragments of a lily pad on a pond design representing one plate. Fragment distribution: 2 (HF), 4 (H), 3 (SF) and 2 (NW) (Fig. 21E).

Twenty red, blue and white floral painted underglaze representing one cup and saucer. Fragment distribution: 4 (HF), 5 (H), and 11 (SF).

Twelve blue and green mottled spongeware underglaze fragments representing one cup and saucer. Fragment distribution: 1 (HF), 2 (H), and 15 (SF).

Four fragments of a deep purple floral underglaze transfer pattern representing one plate. Fragment distribution: 4 (H).

One metalic "gold" banded edge fragment, probably from a plate. This fragment is from (SF).

Three black transfer underglaze fragments exhibiting a spiral design from probably one plate. A partial maker's mark is present (Fig. 20G) which has been identified as that of T.J. & J. Mayer, Longport (Burslem) Staffordshire ca. 1842-55 (Godden 1971:76).

Nine red, blue and black painted underglaze fragments arranged in parallel bands, black leaves are arranged with the red band. A cup and saucer is probably represented. The saucer is 5½ in. outside diameter. All fragments are from (SF) (Fig. 21G).

Four yellow underglaze fragments exhibiting a green and brown painted design, represent a large dish. Base diameter is 5½ in. Fragment distribution: 1 (S) and 3 (SF).

A blue printed maker's mark was recovered. The mark reads: "T...J MAYER LONGPO" (Fig. 20D). Godden (1971:76) identifies this as the mark of Thomas, John, and Joseph Mayer, Longport (Burslem), Staffordshire, ca. 1842-55.

Eight blue underglaze fragments, picturing a landscape, probably from a water pitcher and plate. A makers mark containing the name "VENUS" and "PEARL STONE WARE" is associated with this pattern (Fig. 20F). This design resembles a mark registered in 1849 by Podmore, Walker & Co., Tunstall, Stafforshire (Godden 1971:82). Fragment distribution: 3(H), 4 (SF), and 1 (NW).

Three blue painted dot underglaze design from one cup. Base diameter is 1 3/4 in. A maker's mark of two green painted dots is present. Fragment distribution: 2 from (H) and 1 from (SF).

Seventeen gray and white underglaze restorable fragments from a large ironstone serving bowl rim diameter 11 in., height 2¼ in., base diameter 8 in. Bowl is from (HF) (Fig. 21F).

Two fragments of a blue, yellow and green floral underglaze painted design probably from a plate. A maker's mark is present as a scroll

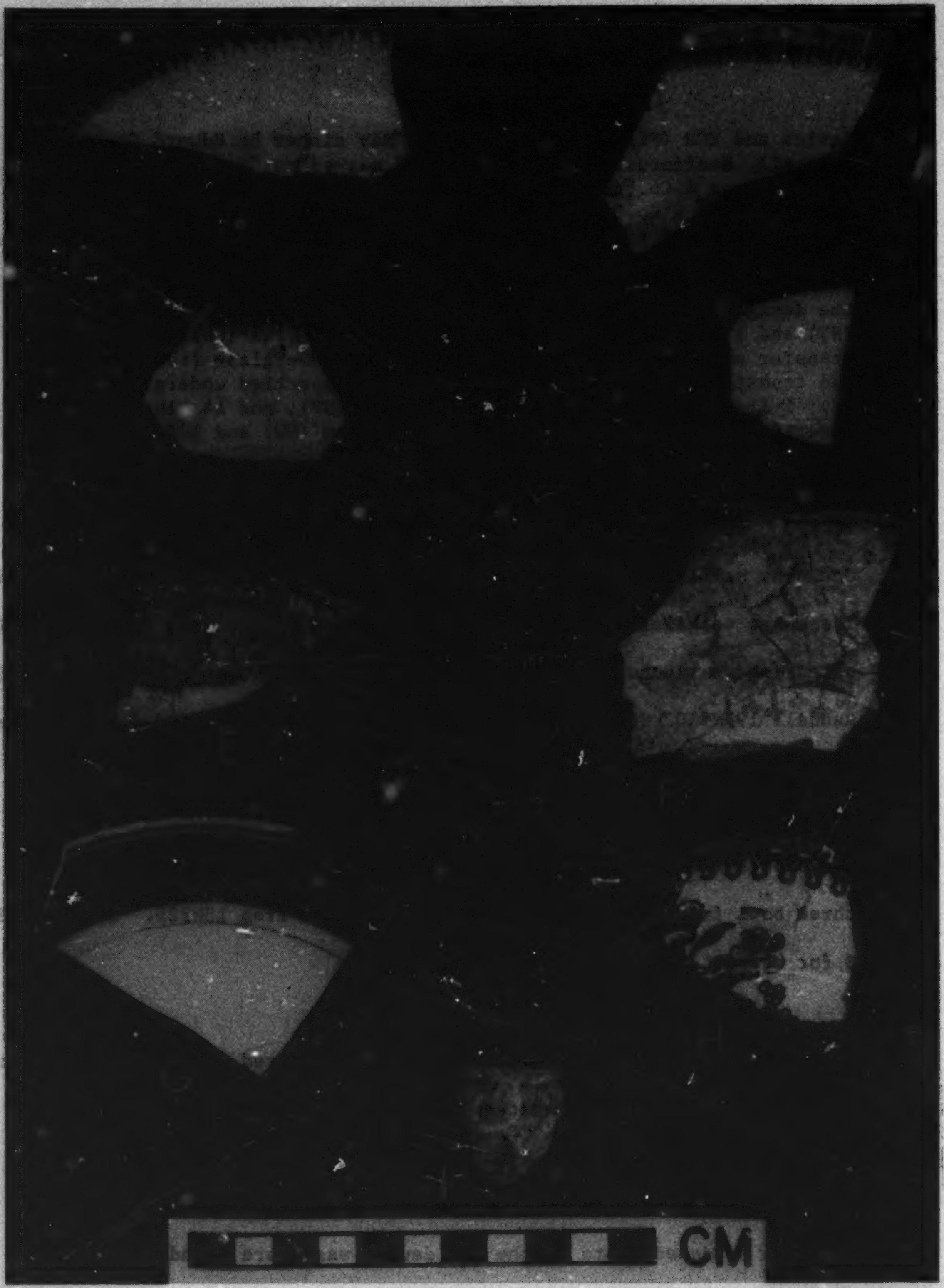

Figure 21. Decorated China Rims and an Effigy Pipe Bowl from 13WP25.

device and ECH (Fig. 20J). The maker may either be Edward Challinor, Tunstall, Staffordshire, ca. 1842-1867 marked as "E. Challinor", or E. Challinor & Co., Fenton, Staffordshire, ca. 1853-1862 marked as "E. Challinor & Co." (Godden 1971:61). Without the entire name the determination of the actual source company is difficult (Fig. 21H).

Twenty six fragments are so minute that only a brief description of the designs are possible: 4 light blue underglaze, 2 from (H), 1 from (SF) and 1 from (S); 2 black lined underglaze from (SF); 2 mulberry transfer underglaze from (H); 1 dark brown underglaze from (SF); 1 red transfer underglaze from (NW) 1 yellow speckled underglaze from (H); 1 light blue striped underglaze from (SF); and 14 blue transfer underglaze: 7 from (H); 5 from (SF), 1 from (NW) and 1 from (S).

Miscellaneous

MARBLE

One clay marble, 1.96 cm (23/32 in.) in diameter was recovered from 13WP22. There are vestiges of a decoration consisting of two dark concentric rings extending continuously around the equator. The surface is extremely pitted. Randall (1971:102) dates clay marbles produced in the United States between 1884-ca. 1920.

PIPES

One pipe stem fragment each was recovered from 13WP22 and 13WP25, and three bowl fragments including one effigy bowl from 13WP25. See Appendix B for complete descriptions.

CASTER

One ceramic furniture caster fragment was recovered from 13WP25, diameter 1 1/8 in., inside bore diameter 3/16 in. Exterior is glazed. The interior paste is very fine in particle size.

MUD DAUBER NESTS

Two fine hardened nests of the mud dauber wasp were found in the floor of 13WP25. Evidently they were attached to the superstructure at the time it burned.

BRICK

The brick from 13WP22 and 13WP25 appears to be locally made. There is much variation in the color due to firing. The 13WP22 bricks are all from Feature 3. Bricks from 13WP25 are representative of those observed.

13WP22

Eight fragments appear to be soft or underfired resulting in a friable structure and an orange color (5 YR 6/8).

One whole brick, 2½ x 4 x 8 ins., has been hard fired, exhibiting a dense, non-oorous, non friable structure and a dark reddish brown color (5 YR 3/4).

Five fragments are of overfired or "clinker" bricks, which have been fired too quickly resulting in spalling of the brick clay body. The color exhibited is a medium dark gray (7.5 YR 4/0). Portions of the outer brick surfaces appear to be glazed in a manner similar to a stoneware slip glaze. The reason for this apparent glazing is not known.

13WP25

One fairly complete soft-fired brick, 2 1/16 x 4¼ x (?) ins. Color is orange (5 YR 6/8) and structure is friable.

Two complete bricks, 1 7/8 x 3 3/4 x 7 3/4 ins., are hard fired and are similar in structure and color to those from 13WP22. One hard fired brick was observed bearing the number "462" which probably represented a batch or lot from the local kiln.

Two fragments of "clinker" bricks, similar in structure and color (7.5 YR 4/0) to those from 13WP22. However, these clinker bricks do not possess a glazed surface.

GLASS

The glassware recovered from 13WP22 and 13WP25 yielded much information. For both historic sites, the glass has been described as completely as possible with the assistance of Katie Foglesong, Ottumwa, Iowa.

13WP22

Seven fragments of an amber colored bottle exhibiting the letters: "RS", "MAC", "L", and "E". This is a probable bitters bottle, possibly "Electric Stomach Bitters" dating ca. 1880-90 (Fig. 22 A and D).

Two fragments, including a neck and base of an amber colored bottle, the base is embossed with a raised circle bearing the letters: "W... & Co. PITTS..." The letter "F" is in the center of the circle. This container could be a whiskey bottle manufactured by Wormser & Co. ca. 1875.

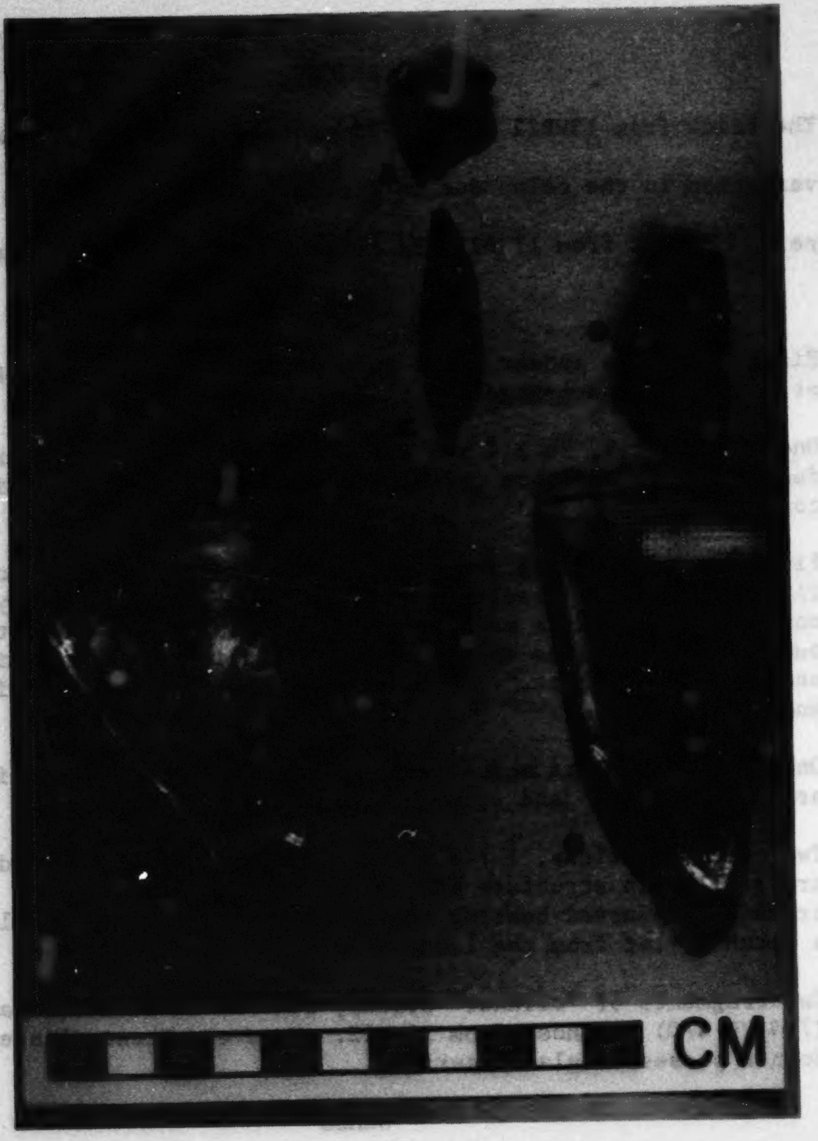

Figure 22. Glass from 13WP22 and 13WP25. A-F, 13WP22; G, 13WP25.

Four fragments from an aquamarine historical-portrait flask. One fragment is embossed with an eagle feather design. Comparable to a specimen in the Foglesong collection. Open pontils preceded the Civil War and the portrait flasks went out of vogue at the end of the Civil War. So we must assume this one was made during Civil war era before 1870 at any rate. No doubt it was made at an eastern glass house--no farther west than Ohio.

Two fragments of an unidentified item (possible bowl). The rim diameter measures 7 in. The glass is colored white and translucent, resembling milk glass but less opaque than milk glass. The exterior is decorated with solid very dark brown opaque circles, in diameter. The lip has been thickened and rounded. The vessel wall curves very slightly inward from the rim.

Five fragments of a goblet exhibiting the petal pattern, dating from 1860's to 1880's, rim diameter 1/8 in. (Fig. 22F).

Seven complete buttons and one fragment. All are 3/8 in. diameter and are white opaque except for one brown opaque specimen. Seven items are 1/8 in. in thickness except one which is 5/32 in. Every specimen is four holed.

One bead was recovered. Utilizing the classification system of Kidd and Kidd (1970), the bead may be described as follows: The bead is a tube which has been probably squared in section before drawing and in drawing the bead was twisted (as Type 1c'). The bead surface was subsequently ground into facets (similar to type 1f) and octagonally shaped. However, the Kidd and Kidd classification system does not display the exact type of bead from 13WP22. The glass is transparent and colored cobalt blue. The bead diameter and length is ½ in. (Fig. 22E).

The remainder of glassware from 13WP22 is listed in Tables 13-16.

Table 13: Bottle Necks from 13WP22 and 13WP25

umber	Neck Diameter	Color	Bottle Type	Method of Manufacture	Provenience
			13WP22		
1	3/4"	Clear	Medicine, Celery salt or household item	Mold	general
1	½"	Aquarmarine	Patent medicine	Mold	general
2	2"	Clear	Food jar	Mold	general
2	3 1/8"	Clear	Food jar	Mold	general
			13WP25		
1	7/8"	Clear	Whisky	Mold	House floor
2	1 1/16"	Clear	Liquor	Mold	House floor
1	½"	Clear	?	Mold	North well
2	7/16"	Aquamarine	Patent medicine	Mold	South feature
1	½"	Aquamarine	Patent medicine	Mold	North well
2	9/16"	Aquamarine	Bitters	Mold	Surface, south feature
1	3/4"	Aquamarine	Bitters	Mold	House
1	½"	Aquamarine	Patent medicine	Mold	House

Source: Foglesong, personal communication and author's analysis

Table 14 : Bottle Bases and Base Fragments from 13WP22 and 13WP25

Number	Shape	Size	Color	Bottle Type	Distinctive Features and/or Manufacturing Methods
				13WP22	
1	round	2 3/4" diameter	aquamarine	mineral water	Probably improved pontil
1	round	2 3/4" diameter	aquamarine	wide-mouthed food	hinged mold
1	oval	1¼" width	light colbalt blue	medicine or whisky flask	diagonal mold seam pre 1880
1	oval	1 3/8" width	aquamarine	shoo-fly whisky flask (Putnam 1965: 177)	mold
1	octagonal	2 3/4"	clear	sugar bowl, creamer, goblet, etc.	star pattern
1	square	indeterminable	clear	food jar	mold
1	round	2 3/4"	sun-purpled	jar	mold
2	square	indeterminable	clear	jar?	mold

Table 14: Bottle Bases and Base Fragments from 13WP22 and 13WP25 (cont'd).

Number	Shape	Size	Color	Bottle Type	Distinctive Features & Manufacturing Methods	Provenience
				13WP25		
1	hexagonal	?	sun-purpled	whisky	mold	house
1	oval	?	aquamarine	elixer or bitters	improved pontil	house
1	round	8 cm (3 1/8 in.) diameter	aquamarine	?	pontil mark	south feature
1	round	?	aqumarine	?	pontil mark	house
1	oval	3.5 cm (1 3/8 in.)	aquamarine	elixer or bitters	improved pontil	house floor
1	oval	?	aquamarine	"	hinged mold	house
3	square	3.9 cm (1½ in.)	aquamarine	?	mold	house floor; south feature
1	round	8 cm (3 1/8 in.) diameter	aquamarine	wine ?	mold	house

Source: Foglesong, personal communication and author's analysis

Table 15 : Lettered Glass from 13WP22 and 13WP25

Number	Color	Item Description	Lettering or Decoration
			13WP22
1	Aquamarine	bottle face	MSAM M/MSM
1	Clear	table ware	stippled background and raised leaf ca. 1880-190
1	Clear	table ware-dish	raised curvilinear pattern-mold blown
			13WP25
1	Crystal	bottle face and base corner	AL/Co./Dayton
1	Aquamarine	bottle face	OR/ES
1	"	" "	C'S C/DIS
1	"	" "	REEN
1	"	" "	DR. C
1	"	" "	85*

*Probable patent date 1885
Source: Fogelsong, personal communication and author's analysis

Table 16: Miscellaneous Glass Fragments from 13WP22 and 13WP25

Color	13WP22	13WP25 Provenience House Floor	House	South Feature	North Well	Surface
Clear	10	35(6)	14 (2)	6 (1)	2	
Amethyst (sun-purpled)			15	1		
Aquamarine	4	52	59	15	5	1
Windowglass	12	3	9	2	3	
Milk glass			3			
Light Cobalt Blue	1					
Lime Green	3					

Source: Author's analysis

13WP25

Bitter's bottle labelled in relief on the base "J. Walker's VB." (Watson 1965: 274) describes a bottle of this style as Dr. Walker's Vinegar Bitters (L 140) sold during the period 1870-1906. This bottle is: mold made, circular in horizontal cross section, conical shoulder aquamarine in color, has an applied lip, is 8½ in. high, and has a base diameter of 3 in. This is the only intact bottle which survived the house fire and was not broken or melted. Provenience: HF.

Four fragments of a quart champaign beer bottle, mold probably no. 15 or 16 (Putnam 1964:253). A rust ring on the neck indicates presence of lightning stopper. The color is aquamarine, circular in shape and is mold made. The bottle is partially melted and unable to be restored. The neck is finished in a bulbous style 14 (Switzer 1974:8, Fig. 2). Accoring to Putnam (ibid.) this bottle probably stood 11¼ - 11½ in. high, was 3½ - 33 5/8 in. wide, held 28 oz. of liquid, and weighed the same amount. The lightning stopper, which was patented in the U S in 1882 (Lorrain 1968:42), dates this bottle between 1882-1906. Provenience: HF.

Ten fragments of a soda or mineral water bottle, probably mold no. 222 (Putnam 1965:240). 7 1/8 in. projected height, bulbous neck finish style 14 (Switzer 1974:8, Figure 2), conical shoulder, chilled iron mold made, aquamarine color, base diameter 2½ in. The heat of the house fire has melted portions of fragments just enough so that the bottle will not entirely resore. Time period 1870-1906. Provenience: HF.

Two fragments of a bottle of Dr. D. Jayne's Expectorant, Philadelphia, ca 1867. Identified from "AD" of Philadelphia embossed on bottle side. The bottle has a hexagonal base and is aquamarine in color. Provenience: HF.

Five fragments of a bottle of Dr. Harter's Elixir of Wild Cherry, (Dayton, Ohio?). Improved pontil mark on oval base, and a horizontal seam across base indicating use of a hinged mold date this bottle 1862-1868. This bottle is two-piece mold made and displays a style 10 neck finish (Switzer 1974:8, Fig. 2). Glass color is aquamarine. Provenience: HF.

Two fragments of a patent medicine bottle perhaps containing a liquid such as children's soothing syrup. An "A" is embossed--very likely as in U S A. A likely possessor of such a lettering is: THE LITTLE DOCTOR/MICROBINE MEDICINE CO./ NEW YORK U S A. This bottle dates probably 1860-1900, more likely before 1900. Proveniences: HF.

Five fragments, including three neck, of hexagonal whisky flasks which probably are Shoo-fly flasks (Putnam 1965:179). They are mold blown, the neck and lip have an added ring which dates ca. 1890. The glass is clear but some sun purpling has taken place. Provenience: HF.

Nineteen fragments of Bourbon Bitters bottle similar to illustration L19 in Watson (1965:251). His description (Ibid.) is as follows: "Shows a seated woman and has a fancy border around the edge. Dark yellow amber three piece mold, push-up base with letter 'p', 9 x 2½ ins. Some fragments of this bottle have been melted and partially fused. The type of bottle was identified from fragments exhibiting letters "URBO" and "RS". Fragment distribution: 8 (HF), 5 (H) and 6 (SF).

Eighteen fragments of a dark green wine bottle dating 1870-1900. The bottle fragments have been partially fused by fire. Fragment distribution: 14 (HF) and 4 (H).

A small cosmetic bottle which probably held cosmetic cream or powder; the four pointed star design and label space indicates that this was not intended for common condiments, dating pre 1900. Provenience: SF.

One fragment of a small hand mirror or picture frame glass. Provenience: H.

One eyeglass lens, shape dates within 1860's. Provenience: NW.

One fragment of sugar bowl, spooner or goblet with "stipled forget-me-not" design popular during late 1870's through 1880's. Provenience: H. (Fig. 22G).

Green bottle base with embossed "G-94/Duraglas" mark of Owens and Illinois Glass which merged in 1920's. Provenience: H.

One clear goblet fragment exhibiting the petal pattern, dating 1860's to 1880's. Provenience: SF.

Two fragments of an octagonal milk glass lamp base, dating ca. 1890. Provenience: H.

Six fragments of a blue-green bottle with a base bearing a pontil scar which dates before 1857 (Lorrain 1968; 40) and certainly before 1865. Provenience: SF.

Two fragments of threaded jar rims. Provenience: H.

One fragment of a clear food bottle displaying a banded and fluted design, pre-1900. Provenience: HF.

Two clear bottle bases dating from the 1920's and 1930's. Proveniences: H and S.

Bottle necks and bases, lettered glass fragments and miscellaneous glass fragments are listed in Tables 13-16.

METAL

Metal items recovered are listed below. Sources useful for identification were unavailable, hence, little more than a brief description is presented. Small metal items are listed in Table 17. Items were categorized as: domestic, i.e., household related; craft/artisian implements, i.e., farm implements or other labor related; and miscellaneous implements.

13WP22

DOMESTIC

1	Three holed tie piece 15/8" square
1	Hinge 2½ in. in length, each half 1 in. in width.
2	Hinges 3 in. in length, each half 1 in. in width.
1	Partial spoon apparently plated; the bowl and handle portion are fragmented.
1	Partial leg such as for a cast iron skillet (Fig. 23 A).
1	Partial leg such as for a fireplace grill or stove
1	Bucket 10¼ in. rim diameter, average thickness 1/16 in. badly fragmented.
1	Round handle 2¼ in. in length attached just below the lip.
1	Curved hook with rivets probably indicating the presence of a handle.

CRAFT/ARTISAN

1	Cow kicker
1	Machinery foot stirrup.
1	Hammer-hatchet 5¼ in. in length.
4	Chain links each 2 in. length.
1	Possible machinery hitch bar
1	Single tree harness piece

Table 17: Distribution of Small Metal Hardware Items

				13WP25				
Dimension Inches	Penny-weight	13WP22	House Floor	House	South Feature	North Well	Figure	Comment - Possible Use
				Cut Nails				
1 length	2 d	7						Finishing?
1¼ "	3 d			1				
1½ "	4 d	11	1	6	1	5	24I	Framing, siding
1 3/4 "	5 d	5		15		2	24G	
2 "	6 d	16					24F	light framing
2½ "	8 d	24	3	35		11	24E	light framing
3 "	12 d	6	1	17		3	24C	Framing
4 "	20 d	1	2	2		1	24B	Heavy framing
				Thin Nails (cut)				
1 1/8 "			1				24K	Barrel (round headed)
1½ "					2		24H	Finishing? " "
1½ "				2			24L	Roofing
1 3/4 "								Metal finishing tack
				Spikes				
2½ "		2		3				Heavy framing
3 "		2						" "
3 3/4 "		2	5	3	2			" "
4 "						1	24A	" "
5½ "	railroad	7						
				Wire Nails				
3 "	12d			1				Framing
				Screws				
1		2						
1 3/4		1						

Table 17: Distribution of Small Metal Hardware Items (cont'd).

Dimension Inches	13WP22	13WP25 House Floor	House	South Feature	North Well	Comment - Possible Use
				Square Washers		
2 5/8 square		1				Hand cut
				Round Washers		
3/8		1				Copper
3/4		1				
1 3/4 diameter		2	1			
1 13/16 "			1			
2 "		2				
2 1/8 "		1				
2¼ "		1	1			
2½ "		1				
				Nuts		
1	1					
1½	1					
2 5/16 square			2			
				Bolts		
3" length					1	
4" "	1					
4 3/8 "			1			
5 "	1					Drop pin in a hitch
6 "	1					Drop pin in a hitch
15 " (½in. diameter)			1			
17 " (3/4 - 1 in. diameter)			1			
				Wire Fragments		
Variable length, each 1/16in. width		4	10	8		
				Miscellaneous Metal Fragments - Unidentifiable		
		4	11	12		

Source· / chor's analysis

DOMESTIC

1 Shotgun hammer assembly (see Appendix D)

1 Copper button shell, ½ in. rim diameter, fastener threaded through hole in center. The name "Scovills & Co. Extra" is stamped around the rim. The name of the firm impressed on this button has undergone some change through time. As Albert and Kent(1949:405)note, the firm of "Leavenworth, Hayedn and Scovill, Waterbury, Conneticut... bought out Abel Porter Company in 1811. Firm name changed to J.M.L. & W.H. Scovill in 1827. Became Scovill Manufacturing Company in 1850. Still in operation." The fact that the impression is "Scovills & Co." and not "Scovill" leads the writer to date this button case between 1827-1850. Provenience: H.

CRAFT/ARTISAN

2 Axle stays, used to keep the wheels on wagon axles; they are metal rings with an outside diameter 1/8 in., inside diameter 3/8 in. (HF).
4 Horseshoes 1 (HF), 2 (H) and 1 (NW)
7 Wagon wheel guard fragments, 6 fragments are 1 in. in width. 3 (HF) and 3 (H), and 1 fragment is 5/8 in. in width (NW).
2 Partial sickles, the first fragment is 43 in. in length and 2 3/8 in. in width, the second fragment is 20 1/8 in. in length and also 6 cm in width. Each fragment exhibits a handle. (HF)
1 Partial brass sleigh bell (SF)
2 Circular harness buckles 3½ in. in diameter with a cross piece bisecting the buckle. (NW).
1 Circular solid ring 2 in. in diameter with central threaded socket, possibly from a wagon (H).
2 Partial corn planter checker plates - two types are present:
1 9½ in. diameter, 5/8 in. hole diameter, holes are spaced 3/16 in. apart around 3/16 in. apart around the plate rim (H). Fig. 23E).
1 9 in. diameter, ¼ in. hole spacing, alternating 3½ in. oval and ½ in. holes spaced around the plate rim (H). (Fig. 23F).
2 Buggy or wagon straps and springs with U nails for attachment (H)
1 Cow bell 5 3/8 in. length, 3 3/4 in. at shoulder, 4 3/4 in. at base. Bell has a hanger attached, clapper is missing. Bell has been flattened somewhat. (HF).

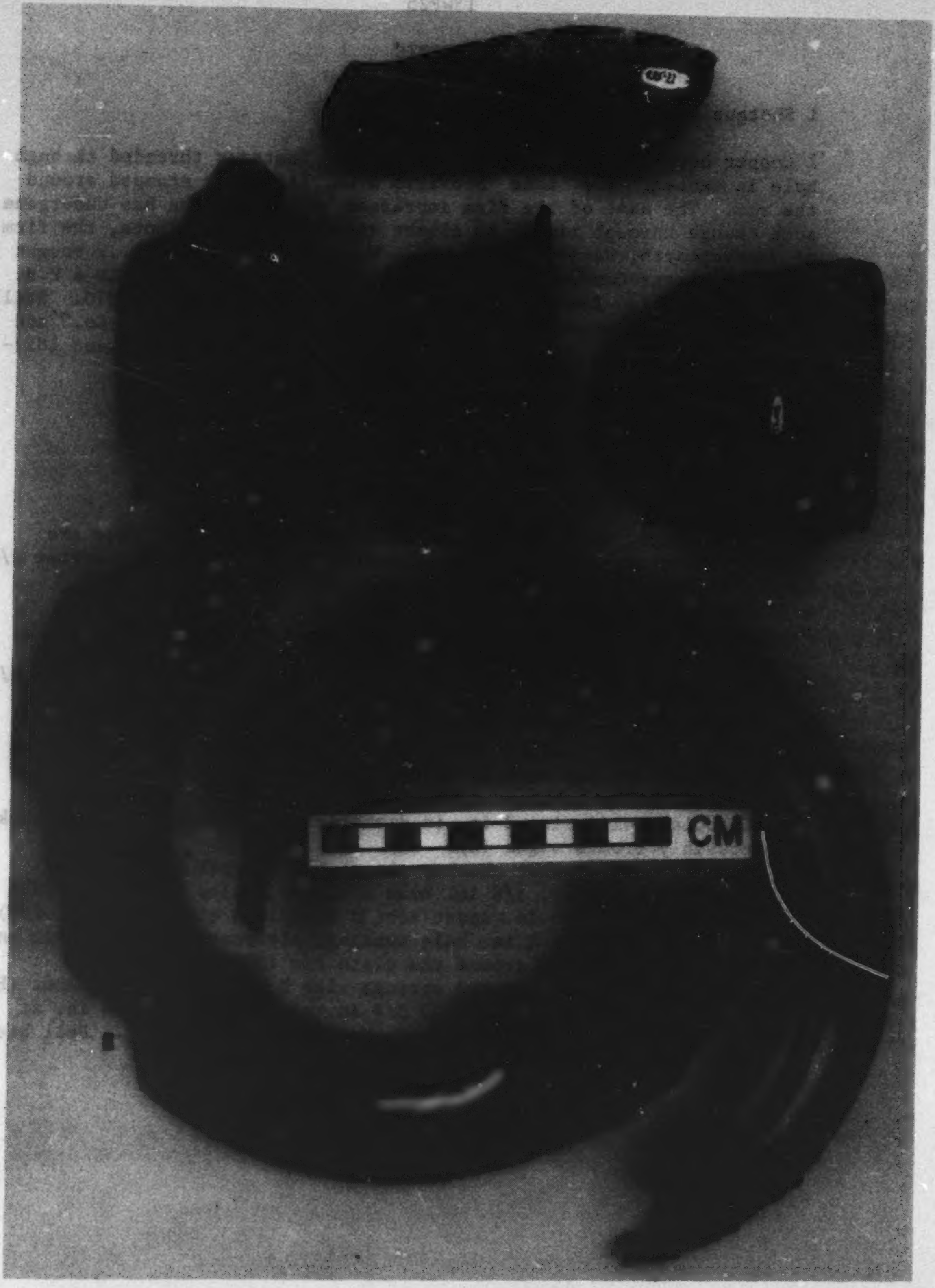

Figure 23. Metal Items from 13WP22 and 13WP25.

NON-CATEGORICAL

1	Bar 9½" in length, 7/8" in width, convexly shaped on one side expanding to a thickness of 1/8"
4	Unidentifiable cast iron fragments
1	Small bar, elongated U shaped, 1 3/16" in length, 1/16" in diameter - possible belt buckle fragment.

13WP25*

DOMESTIC

1	Kerosene lamp wick holder (H)
2	Kitchen stove ash grate (HF)
3	Drawer pulls (HF) (Fig. 23B, 23C).
1	Door latch and handle assembly (HF)
21	Bucket pieces 1/16 in. thick 13 (HF), 5 (H), and 3 (SF)
10	Bucket pieces 3/4 in. thick (SF) one piece is marked with an embossed "I"
1	Complete bucket handle with a looped center for hanging or tying complete with rivet assembly (HF)
2	Cylindrical window counter balances 6 in. long and 2½ in. in diameter 1 (HF) and 1 (H).
1	Probable cupboard handle
5	Spoon fragments including 3 bowls. 1(H) and 2(NW)
1	Perforated end handle (H)
1	Plain handle stamped with a maker's mark: C & S, (NW). (Fig.24N).
1	Stove firebox knob (H)
2	Hinge fragments and 1 complete hinge (H)
3	Door lock assemblies (H) (Fig. 23 D is an example).
1	Drawer lock plate (SF)
1	Door lock plate (H)
1	Strap hinge (H)
1	Belt buckle (H)
2	Garter or suspender buckles (H)
1	Copper boiler lid, partially fragmented (HF)
1	Wrought iron (fence top?) decoration (H)
29	Barrel hoop fragments

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* Provenience abbreviations: H-house; HF-house floor, SF-south feature, NW-north well, and S-surface.

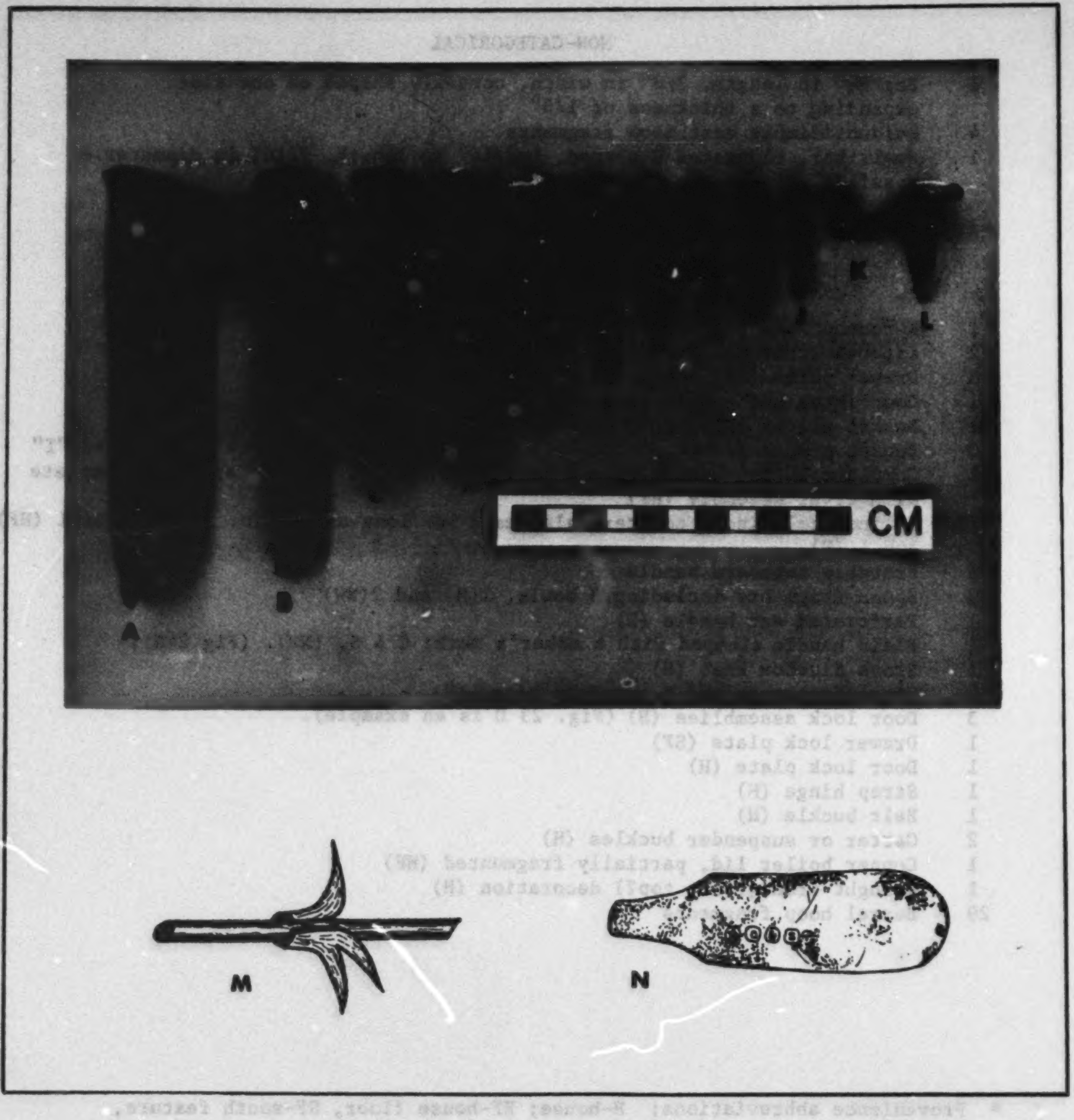

Figure 24. Small metal items from 13WP22 and 13WP25. A-L, nails; M, Kennedy's Barb, three-point variation (from Clifton 1970, No. 211); N, spoon handle impossed with "C & S."

1 piece of barbed wire appears to be Kennedys Barb, Three point Variation which is described as a single-strand wire with three-point sheet metal barb. Barb is hand mounted. Variation of patent 153965 (Clifton 1970:74). The date of patent 153965 is August 11, 1874 by Charles Kennedy of Hinckley, Ill. (Clifton 1970:76). (Fig. 24M).

6	Chain links 1½ in. outside length of individual link (HF).
1	Axe head, butt length 3 9/16 in., butt width 1 3/8 in., body length to greatest width on bevelled end 7 1/8 in. (NW).
5	Sickle mower blades, 3 (HF), 1 (H) and 1 (NW).
1	Axle shaft cap? 3½ in. outside diameter (NW).
2	Hooks (H).
1	Wheel guard washer and nail assembly (H).
1	Flat bed machinery support. (H).
1	Three prong pitchfork, center prong broken, overall length 12 in.(H).

NON-CATEGORICAL

1	Bar 21½ in. length, 9/16 in. diameter (HF).
1	"U" shaped strap, 2 in. in width and 24 in. in overall length (H)
1	Bar 1 in. in width, 13½ in. in length (H)
1	Bar 3/8 in. diameter, 1 ft. length, "L" shaped bend at both ends (HF)
2	Wire ovals 3 7/8 in. in length and 1 3/4 in. in width. (H).
1	Double open ended copper tube 1 1/16 in in length (H).

LEATHER

Seven fragments of a badly decayed shoe were recovered from 13WP25.

The following parts are recognizable:

2 fragments from one nearly complete sole. The length is ca. 8 in., width is ca. 3 in. at the instep. The outsole is fastened to the insole by small brass screws. Anderson (1968:59,64) dates this construction as occurring after 1862.

FAUNAL MATERIAL

Description and interpretation of this material is presented in Appendix C.

Discussion

While the scope of this report is primarily descriptive, the historical research conducted and the material recovered will provide useful data for future investigation and interpretation. Both sites are unique archaeologically and the materials recovered are worthy of further study.

Judging from the mean date of diagnostic china and glass, 13WP22 was an active sawmill ca. 1875. As might be expected, most artifacts recovered fall into the utilitarian category. At 13WP25, there is evidence to suggest that most of the materials recovered date from the McQuiston occupation of the house. The mean date of diagnostic china, glass and metal can be set at ca. 1862. Since the records indicate that McQuiston took out a mortgage on the land in 1869 and a structure is shown on the property by Warner (1870), one assumes that he brought many of his possessions with him. The occupational debris may, therefore, be representative of a rather short occupation as McQuiston is known to have lost title to the land in 1871. One beer bottle (1882-1906), one piece of barb wire (1874) and various bottle fragments (1920-30) may have been introduced at a later time, assuming that the house cellar was open for a period of time after the house burned.

The apparent tight cluster of artifacts found within the house fill, well and south feature indicate that the structure may have burned at the close of the McQuiston occupation indicating that subsequent tenant farmers lived elsewhere. Artifact patterns at both 13WP22 and 13WP25 are consistant with what one would expect to find considering the time of occupation and social position of the occupants. Materials recovered were basically utilitarian in nature. At 13WP25 there is an indication from the faunal analysis that wild as well as domestic animals were taken. The absence of deer is noteworthy (see Appendix C), perhaps suggesting that hunting was less important to the economy of the McQuiston family than the use of domesticated animals. Judging from the farm implements, much of the family's economy was based upon crops raised. Perhaps as more is learned through the excavation of other sites of this time period the assemblages from 13WP22 and 13WP25 will be of greater interpretive value.

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Appendix A: A History of the Potters in Dahlonega, Iowa

During the Phase II investigations at 13WP25 a stoneware rimsherd was recovered bearing the impressed stamp "DAHLONEGA" / "5". This sherd aroused the writer's curiosity and research was initiated to determine the date and place of manufacture, and identity of the manufacturer.

County histories were consulted initially. The Western Historical Company (1878:539) relates that in 1856 "...the records show...an extensive pottery...." Waterman (1914:315) stated that: "in the early days there was a pottery shop, long operated by L. F. Stewart, not quite a mile west of the town of Dahlonega." Waterman (ibid.) apparently referring to sometime in the 1850's notes that "in the town of Dahlonega there was also a pottery shop here about this time, run by one Haswell." These brief references formed the basis for further inquiry.

Iowa state gazetteers were next examined. The earliest, Hair (1865:593), listed a potter in Ottumwa, John P. Williams, but none in Dahlonega. R. L. Polk (1882:1088) entered as a subscriber "Underwood--Dahlonega." No subsequent listing of any pottery in Dahlonega was noted in state gazetteers from 1884-1922.

The 1856 census of Iowa (Iowa Census Board, 1856 ms, vol. 65: 119, 139) lists the following potters in Dahlonega township:

Name	Age	Years in Iowa	Place of Previous Settlement	Land Ownership
L. T. Stuart	32	9	Indiana	Yes
James Smith	23	13	Indiana	No
James W. Catterson	24	1	Kentucky	No
John Reece	33	9	Pennsylvania	?

L. T. Stuart is apparently the potter referred to in Waterman (see above).

A brief ground inspection of the town of Dahlonega produced an apparent stoneware waster (refuse) pit which contained kiln furniture similar to the types discussed in Reynolds (1969 ms) and Schulte (1974 ms). This waster pit produced a stoneware rim exhibiting an impressed stamp comparable to that from 13WP25 (Fig. 25). The location of this waster pit is in Dahlonega, Block 6, West one-half of Lot 6 (see Fig. 25). The Dahlonega plat book of McElroy, Truitt and Truitt (n.d.b.) was searched for the above location, the results of which are displayed in Table 18 . The name of L. T. Stewart appears and apparently owned property in this location from April 13, 1853 to September 29, 1856 when he relinquished his deed.

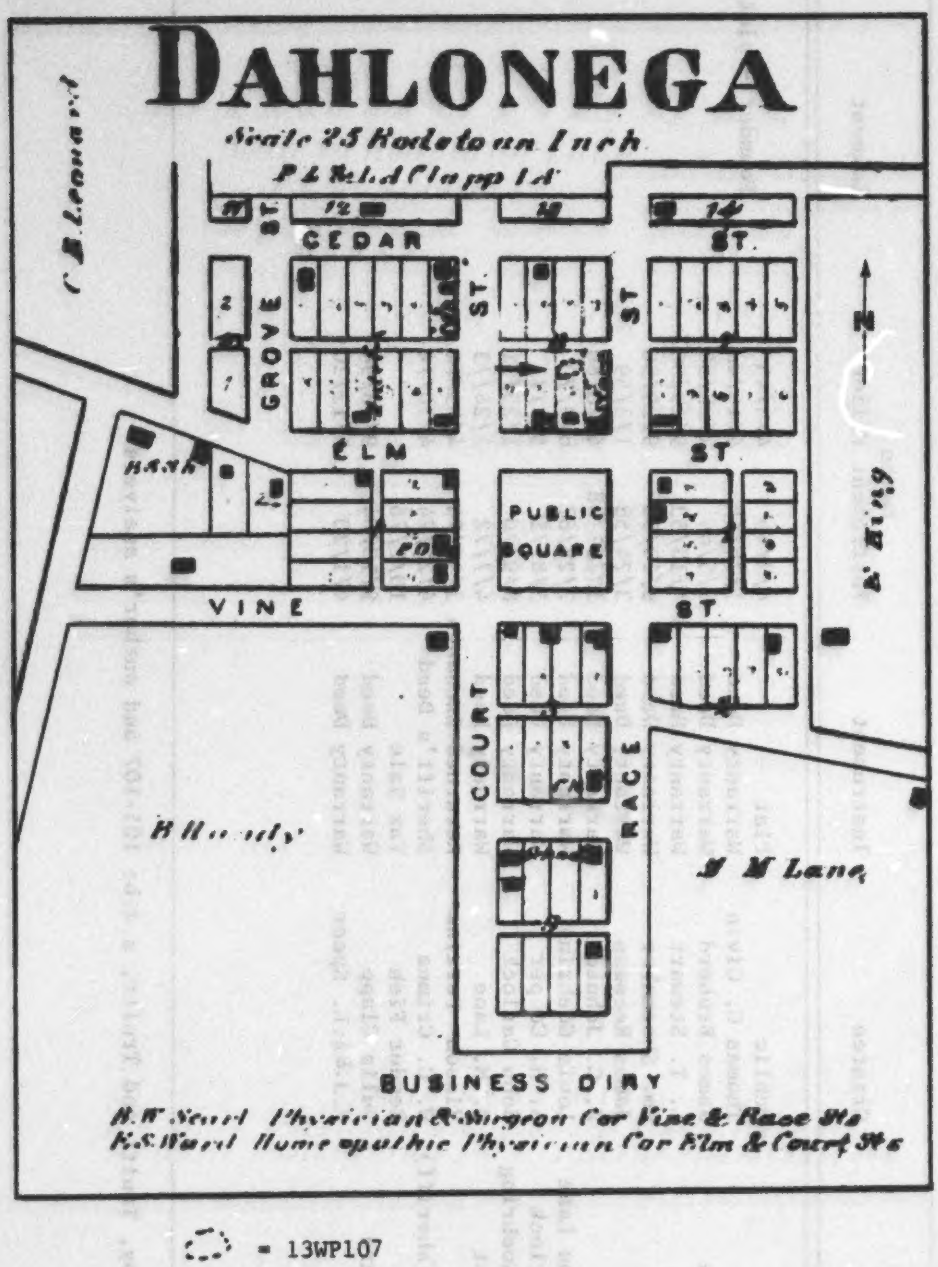
L. T. Stuart's (or Stewart) name did not appear in any subsequent land transactions in Dahlonega or Dahlonega township. Stuart apparently had moved from Dahlonega. His subsequent domicile was a matter of speculation until examination of Iowa state gazetter of R. L. Polk & Co. (1883:1088) for 1882-83, and 1884-85 (1885:1303) revealed "Stuart & Burley, Blakesburgh." At first I was not certain whether the Stuart listed was L. T. but the Polk gazetteer for 1889-90 (R. L. Polk 1890:1438) verified this.

A stoneware crock in the Wapello County Historical Museum is stamped with the name Blakesburg impressed in a lettering style similar to that found on the Dahlonega ware, strengthening the contention that the same man, Stuart, was responsible for both. Further evidence should be obtained by comparing material from the Blakesburg kiln with that from Dahlonega.

Now that L. T. Stuart has been identified, what of "one Haswell?" Haswell is not listed in the census for 1856 but he is listed in the tax record for 1857 (Wapello Co. Recorder's Office 1857: no page) as Nathaniel Hoswell residing at Lot 6, Block 4, and having $2.50 in delinquent taxes due. This is the only record observed on Hoswell. Apparently he roomed fairly close to the location of the waster pit. Unfortunately there was no direct evidence that Hoswell ran the pottery shop for Stuart other than the reference in Waterman (ibid.).

Reproduced from best available copy.

Figure 25: Location of the Stuart Waster Pit, 13WP107



Source: Warner 1870 and author's analysis

Table 18. Transfer of Land in Dahlonega, Iowa, Block 6, West One-half of Lot 6 and Lot 7

Grantor	Grantee	Instrument	Dates Instrument	Filing	Comment
John Moore	Public	Plat	4/2/45	4/3/45	
John Moore	Thomas G. Givin	Warranty Deed	1/26/48	4/15/48	Founder - platted all blocks
Thomas G. Givin	James Broherd	Warranty Deed	9/5/49	2/22/50	
James Broherd	L. T. Stewart	Warranty Deed	4/13/53	9/29/56	
L. T. Stewart	Wm. Shoemaker	Warranty Deed	9/19/56	9/29/56	
Wm. Shoemaker	James Reesman	Warranty Deed	3/24/58	1/3/59	
James Reesman	J. C. Johnson	Warranty Deed	12/31/58	4/20/60	
M. M. & Caroline Lane	Louis Goehring	Warranty Deed	2/28/67	8/9/70	
John & Mary Garlock	A. H. Cooper	Warranty Deed	5/8/71	5/8/71	
Lewis & Ellen Goehring	John Garlock	Warranty Deed	8/9/70	1/25/71	
Amos & Mary West	M. M. Lane	Warranty Deed	4/7/72	1/24/73	
W. C. Grimes	Vinson Perkins	Returned Exchange	3/30/74	4/25/74	
T. P. Spilman (sheriff)	W. C. Grimes	Sheriff's Deed	4/25/74	4/30/74	
W. C. Grimes	Reeder Fish	Tax Sale	10/2/76		
E. S. & Mary Ward	Julia Clapp	Warranty Deed	9/13/94	9/18/94	
Julia C. Clapp	R.J.&A.L. Speer	Warranty Deed	4/1/20	4/12/20	

Source: McElroy, Truitt and Truitt, n.d.b: 105-107 and author's analysis

In the period after Stuart left Dahlonega, a potter from Ohio, John Richards, was in town in 1870 (Iowa Census Board, 1870 ms, Wapello Co:390. Nothing further is known concerning Richards, either before or after 1870. He may not have been a land owner or a resident as he is not listed in the land transfer books and does not appear to be connected with the location of the Stuart waster pit.

L. T. Stuart has been traced fairly satisfactorily. However, the potter "Underwood -- " listed in Polk(1882) is still an enigma. As Underwood is not listed in state gazetteers of the late 19th century, Ottumwa city and Wapello county directories were examined. Merritt and Goodwin (1886) list a J. H. Underwood & Son pottery on Richmond in Ottumwa (p.146); and J. H. and F. E. Underwood are listed as residing on the same street (p.113). Sutton Publishing Co. (1887) contains the following information: Potter Fred E. Underwood, residing on the north-south state road, south side (p.187); Joseph H. Underwood, same occupation and address as Fred E. (p. 188); the South Ottumwa Pottery Co., J. H. Underwood, proprietor, located on the north east corner of 2nd and Ferry, also on the south side (p.216); and a note that Joseph H. Underwood owns lots in Dahlonega (p.266). No author (1890) enters F. E. Underwood as working in Morrels Meat Packing Plant and residing at 315 Ward Street in 1890-1891. F. E. Underwood, Cooper, and J. H. Underwood, propietor of pottery works reside on the north side of Richmond are, south side of Ottumwa (no author 1892:187) and Underwood's pottery works are at the corner of Ferry and Richmond (Ibid.: 249). The Underwoods are not listed in subsequent city directories. A newspaper article in a scrapbook (No Author 1891:7) mentions" J. H. Underwood; pottery; located in South Ottumwa ten years.)

The Census of 1885 (Iowa Census Board, 1885 ms, Wapello Co.: 210-212) list the following potters in South Ottumwa:

Name	Age	Place of Birth	
J. H. Underwood	53	Ohio	)
Fred E. Underwood	18	Union Co., Iowa	) same household
Howard E. Sowers	28	Ohio	)
Burt Weingardner	27	Des Moines Co., Iowa	)
Thomas B. Franklin	26	New York State	) same household
August W. Melcher	42	?	)

The Special Census of Ottumwa (Ottumwa City Council 1891; Fifth Ward: no page) lists J. H. and Fred E. Underwood. But by the 1895 Census (Iowa Census Board 1895 ms) the Underwoods have apparently moved, as they are no longer listed.

In sum, until further evidence can be gathered, a tentative date of 1853-1856 may be assigned to Stuart's pottery kiln in Dahlonega, after which he probably moved to Blakesburg where he was in operation until about 1890. In the meantime, potter John Richards was in Dahlonega in 1870, but the location and extent of his stay there is not known. As for the Underwoods, they seem to have moved to Wapello County from Union County, Iowa (where Fred Underwood was born). Apparently, Joseph Underwood started his pottery in 1881, either in Dahlonega or South Ottumwa. (He may have had an outlet in Dahlonega) but by 1886 the Underwoods were running the South Ottumwa pottery works and the only connection with Dahlonega was ownership of lots there by Joseph H. Underwood. The Underwoods continued to run the South Ottumwa works until at least 1892 after which no mention is found of J. H. or Fred E. Underwood in either directories or census records.

The location of the Underwoods' pottery works in South Ottumwa should be determined, as should Stuart's in Blakesburg so that the material can be collected and compared with that from the Dahlonega waster pit (13WP107), 13WP22 and 13WP25. It is important to know the extent of traffic of items from local kilns such as those of Dahlonega, Blakesburg, and South Ottumwa in order to trace economic networks in the 19th century Iowa.

Appendix B: Analysis of Clay Tobacco Pipes from 13WP22 and 13WP25

Margaret Hotopp, Department of Anthropology
University of Iowa

Clay tobacco pipes are found in abundance in American historic archaeological sites, especially the sites of old forts. Large numbers of the fragments have been recovered from Fort Laramie, Wyoming; Fort Union, New Mexico; Fort Pierre II, South Dakota; and Fort Atkinson, Iowa. This abundance must be due in part to the extremely low cost of the pipes, "varying . . . from 50 cents to $1.20 per gross" (Wilson 1961:123). The low cost was the result of the industrial revolution in Europe which mechanized pipe production in the middle eighteenth century. The first clay pipes were introduced in Europe during the sixteenth century, possibly by the British, who were prohibited by the Spanish from obtaining the preferred Havana cigar. Hence, most tobacco imported by the British was in the form of leaves. Since professional cigar rollers were rare in Britain, the most desirable alternative was to smoke the shredded product in a pipe (Humphrey 1969:13). The earliest reference to pipes in England appears to be that of William Harrison, who, in 1573, described the practice of "the taking in of the smoke of the Indian herb called Tobacco, by an instrument formed like a little ladell . . ." (quoted in Oswald 1961:55). At this time, pipe-makers organized themselves into guilds and produced relatively small numbers of distinctively marked pipes. But the industrial revolution forced those who would not mechanize out of business, and a relatively few manufacturers began producing large numbers of pipes (Humphrey 1969:14).

To make a pipe, a fine-grained plastic white clay, kaolin, was first worked with water into a thin paste and then seived to remove impurities. After the water evaporated, the clay was kneaded and a small glob was rolled into a cylindrical shape to form the stem. A second glob was attached to this cylinder to form the bowl. The clay was then allowed to dry further for a day or two, and when ready, placed in a hinged two piece mold - each half being one half of a pipe cut lengthwise. Before the mold was clamped shut, the bore was formed by inserting a long iron wire into the soft clay stem. The mold was then closed tightly. A lever was brought down which pressed an oiled stopper into the bowl of the pipe, forming the cavity. The bore wire was then pushed through the final few milimeters to join the cavity. At this point, the wire was removed, the pipe taken out of the mold, and excess clay scraped away with a knife. Finally, the pipes were carried to the kiln where "50 gross could be fired in from 8 to 12 hours. A boy and a workman could easily make five gross of pipes in a day's time" (Wilson 1961: 123).

The interior of the mold could be decorated in many ways, producing the variety of designs exhibited by clay pipes. The designs are most often in relief due to the ease in which the interior of the mold could be carved or stamped. It is somewhat more difficult to produce raised designs in the mold which cut into and incise the design on the pipe. And just as many molds were left undecorated, producing smooth, plain pipes whose only variations occur in the basic shape of the pipe and the mold line treatment. Mold line treatment varies as well on the decorated pipes. The mold line was most often scraped flat before firing. Occasionally, the mold line was flattened by cutting in a series of incised diagonal lines, and often the mold line was left unmodified. Many decorated pipes exhibit an additional method of mold line treatment: a row of leaves is displayed on either side of the unmodified mold line. The mold line is thus incorporated into the design as the stem out of which the leaves grow (Humphrey 1969:14).

Description of Clay Pipe Fragments

from 13WP25 and 13WP22

Catalogue # 435-25-2(1) This bowl fragment corresponds to the 26 specimens of Ribbed Type I from the Fort Atkinson, Iowa collection (Hotopp n.d.:25-26 and Fig. 5A). The ribs begin midway down the bowl and alternate in width from a thin raised line to a rib approximately 1/8 inch wide. The mold line has been flattened with incised diagonal lines. Ribbed Type I corresponds to Hanson's Ribbed Variety A pipes from Rome, New York. Hanson believes these pipes were manufactured in England (Hanson 1971:94).

Catalogue # 435-25-2(2) This bowl fragment is ribbed but the type cannot be determined. The fragment is thicker than most, approximately ½ inch. A narrow lip encircles the rim of the bowl.

Catalogue #435-25-3 This effigy bowl fragment is in the form of a human head. It is remarkably similar to a specimen from Fort Union, New Mexico, described by Wilson (1966:39 and Fig. 6D) as follows: "Made of red clay, the figure represented is a heavily bearded man with a head of long hair. His appearance suggests the biblical Sampson". The specimen from 13WP25 is made, however, of white clay. Furthermore, the lower portion of the face is missing, and although a moustache is present, it is impossible to know if the figure was bearded.

Catalogue # 435-25-4 This specimen is an undecorated stem fragment and is not diagnostic. The mold lines have been scraped before firing.

Catalogue #435-22-2 This stem fragment is of the type associated with the Ribbed Type I bowls (see above) from the Fort Atkinson collection. The ribs on the bowl terminate just beyond the spur in four parallel raised lines encircling the stem.

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Appendix C: Faunal Analysis of the McQuiston Historic House Site (13WP25), Wapello County, Iowa

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University of Iowa

Bone excavated from the McQuiston historic house site (13WP25),Wapello County, Iowa was divided into three categories for examination: (1) readily identificable material, (2) potentially identifiable material, and (3) unidentifiable material. Category one bone included two wild species (fox squirrel, Sciurus niger and cottontail rabbit, Sylvilagus sp.); five domestic animals (chicken, pig, sheep, cow, and horse); and a turkey humerus which may be either wild or domestic.

Twelve of the 20 identified individuals (Tables 19 and 20) were domestic and these represent over 99 percent of the available meat, irrespective of the horse (White, 1953). Evidence of butchering with a saw was clear in both the sheep and cow. No butcher marks were evident on the horse or pig. Both knife and saw marks were present in potentially identifiable remains. The pigs were killed (or died) while young. Only 2 of the 32 identified pig elements had distal fusion on the epiphyses and none were fused proximally. Judging from its complete skeletal count (Table 19) the horse either fell or was discarded into the well.

Category two material consisted of skeletal elements that can be identified to element, but not readily to species. Specific identifications were precluded either because of fragmental nature or insufficient comparative material in departmental collections. These elements included three scapula fragments, an ulna fragment, 12 rib fragments (5 with saw marks), eight cervical vertebrae (four sawed longitudinally and two with knife faceted articular surfaces), and four thoracic vertebrae (2 sizes).

Table 20 outlines the faunal distribution within the site. Each unit (basement floor, house fill, refuse pit, well, and surface deposits) contained at least four different species. Both the house fill and the well contained five species. While the counts are small, it appears that animal bone was randomally distributed throughout the site. Exact counts per provenience unit were not attempted because of small sample size. Also, the volume of matrix from which skeletal material was recovered was quite different for each unit (John Tandarich, personal communication).

Horse and sheep (Hildebrand, 1955) remains have been cataloged into the recent comparative collection, Department of Geology, University of Iowa in order to augment the domestic sample. All other bone has been returned to the Office of the State Archaeologist. It is recommended that all unidentifiable bone scraps and perhaps portions of the surface sample be discarded. Other remains should be saved for future analysis of trace elements.

LITERATURE CITED

Hildebrand, Milton, 1955. Skeletal differences between Deer, Sheep, and Goats. California Fish and Game 1955: 327-346.

White, Theodore, 1953, A method of calculating the dietary percentage of various food animals utilized by aboriginal peoples. Am. Antiquity: 18: 396-398.

Table 19. Identified skeletal elements from the McQuiston Historic House Site (13WP25), Wapello County, Iowa

	Chicken	Turkey	Squirrel	Rabbit	Pig	Sheep	Cow	Horse	
Skull	-	-	-	-	-	-	-	1	
Mandible	-	-	1R	-	2L&2R	-	-	1L&1R	
Scapula	-	-	-	-	-	-	-	1L&1R	
Humerus	4L&5R	1R	1L	2R	2L&4R	-	-	1L&1R	
Ulna	1L&1R	-	1R	1L	3L	1L&1R(b)	1R	1L&1R	
Radius	1L&1R	-	1L	1L&1R	2L&3R	1L&1R	1R	1L&1R	
Innominate	0	0	-	-	1	-	1	1	
Femur	2L&1R	-	2L	2L&4R	3L&3R	-	-	1L&1R	
Tibia	0	0	-	5R&2L	3L&2R	1R	1R	1L&1R	
Calcaneum	0	0	-	-	1	-	1R		
Metapodial	0	0	-	2	1	1(b)	-	1L&LR	
Coracoid*	1	-	0	0	0	0	0	0	
Sternum*	1	-	0	0	0	0	0	0	
Carpometa-Carpus	1L	0	0	0	0	0	0	0	
Tibiotarsus*	2L&2R	-	0	0	0	0	0	0	
Tarsometa-*tarus	2L&2R	-	0	0	0	0	0	0	
Minimum Number Individual	5	1	2	5	4	1	1	1	20

Legend:

- Not identified

* Present only in birds

0 Not present in animal

b) Burned (cow): Ulna frag, distal tibia epiphysis, vertebra centrum and 14 fragments of bovid size

Table 20. Distribution of Faunal Elements in the McQuiston Historic House Site (13WP25), Wapello County, Iowa

	Basement Floor	House Fill	Refuse Pit	Well	Surface	Minimum Individual	Genus
Chicken	x	x	x	x	x	x	*Gallus*
Turkey	-	-	-	-	x	1	*Meleagris*
Squirrel	-	x	x	x	-	2	*Sciurus*
Rabbit	x	x	-	-	x	5	*Sylvilagus*
Pig	x	x	-	x	x	4	*Sus*
Sheep	-	-	x	-	-	1	*Ovis*
Cow	x	x	x(b)	x	-	1	*Bos*
Horse	-	-	-	x	-	1	*Equus*

Legend:

x: Recorded from unit

-: Not recorded from unit

(b): burned specimens present

Appendix D: The McQuistan Historic Site (13WP25) Gun Lock

Holmes A. Semken Jr., Dept. of Geology
Richard M. Schieken, Dept. of Pediatrics
University of Iowa

No marks remain on the McQuistan gun lock to identify its manufacturer, but it can be catagorized as a military rifle lock. It is too heavy for a commercial rifle or shotgun and smaller than a standard musket lock (Fig. 1A & B.) It is the size of a U.S. Model 1841 rifle lock and closely resembles a variety of European military models, comparing best with those of Prussian and Austrian origin.

The "lazy S" - shaped hammer and the short forend (distance dg, Fig. 1A) suggest that the lock originally was a flintlock and that it subsequently was converted to percussion ignition. The scarcity of flintlock arms today partially is a result of their having been modified to the more modern percussion system in the middle 1840's. Wholesale conversion of government arms was accomplished by removing the flashpan, frizzen, frizzen spring, and filling the touch hole. A percussion nipple to hold the cap and a single piece hammer was then installed. The mortise for the frizzen screw and frizzen spring screw (Fig. 1A) was filled by cutting their respective screws off flush with the lockplate. External evidence of the mortise for these screws is concealed by rust on the McQuistan lock. A radiograph (Fig. 1C) taken at 125KV clearly reveals the present of both the frizzen screw and frizzen spring screw mortise and confirms that the McQuistan specimen originally was a flintlock.

It is also clear from the radiograph that a new mainspring was inserted during or after conversion to percussion. Most flint weapons had a mainspring retaining screw (Fig. LA & C). These frequently were abandoned on percussion

Arms, the strength of a longer upper branch and the mainspring pivot being sufficient to hold the spring in place. The old mainspring screw mortise is visible on the McQuistan specimen (Fig. 1C). A broken mainspring rendered the lock useless. This break can be seen in Fig. 1C just below the diagonal white line. This malfunction is confirmed by the main spring being in the "cocked" position while the tumbler and sear are in the fixed position (Fig. 1C). Missing side plate lock screws indicate that the lock was separated from the gun prior to being discarded into the McQuistan well. Also, no other gun parts are associated in the collection of artifacts from the well.

The lock is preserved in the State Archaeological collections.

LITERATURE CITED

Anonymous, 1976, This Issue's Cover Story, Medical Radiography and Photography, v. 52, n. 1, inside cover.

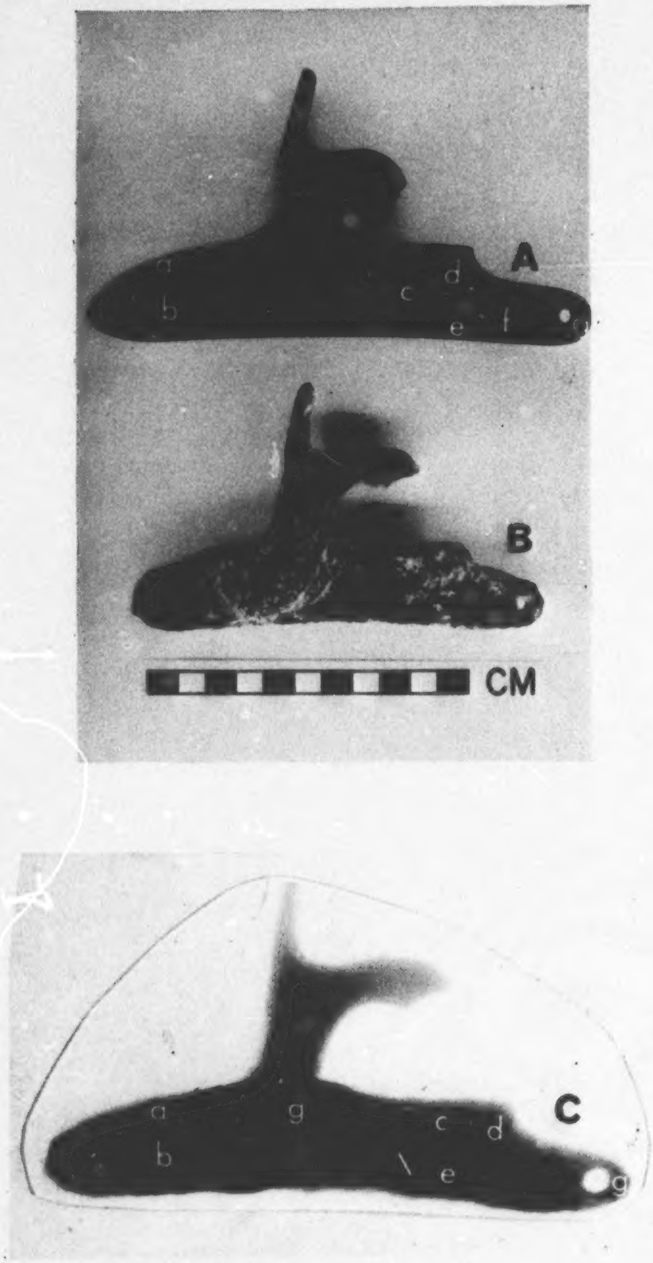

Figure 1. Gun locks converted from flint to percussion. A, Exterior view of U.S. Model 1816 musket lock, Nippes Contract; B, Exterior view of lock from McQuistan Historic Site (13WP25); C, Radiograph of the McQuistan lock. Nomenclature: a, sear spring screw; b, sear screw; c, mainspring retaining screw; d, frizzen screw; e, frizzen spring screw; f, mainspring pivot; g, lock plate side screws; line in radiograph--fracture position of McQuistan lock.

APPENDIX B

AQUATIC BIOLOGICAL DATA

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B-2	Phytoplankton - Station 2 - Upper Des Moines River
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B-4	Phytoplankton - Station 4 - Upper Avery Creek
B-5	Zooplankton Analysis - Des Moines River & Avery Creek
B-6	Periphyton Analysis - Des Moines River & Avery Creek

Figure No.	
B-1	Sampling Points

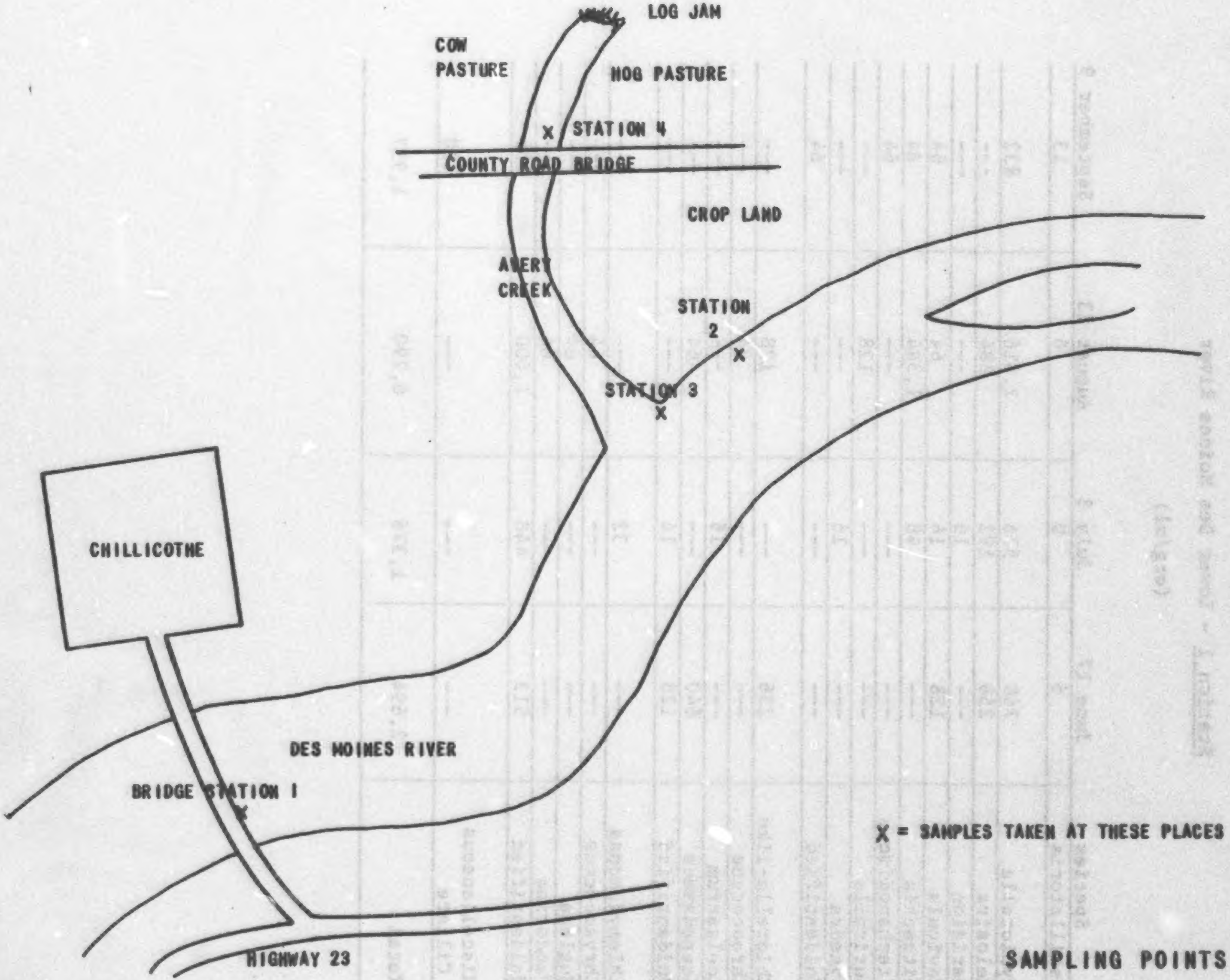

FIGURE B-I

SAMPLING POINTS

Table B-1

Phytoplankton

Station 1 - Lower Des Moines River

(org/ml)

Species	June 17	July 8	August 13	September 9
Oscillatoria	6	0	6	13
Cyclotella	768	576	2,816	832
Melosira	256	192	384	---
Meridion	---	16	---	---
Navicula	128	16	64	64
Nitzschia	---	48	1,344	64
Stephanodiscus	---	---	---	64
Surirella	---	---	128	---
Synedra	---	16	---	---
Unidentified	---	---	---	64
Chlorella-like	256	---	128	---
Chroococcus	---	---	64	---
Coelastrum	---	16	---	---
Scenedesmus	640	---	64	---
Unidentified	128	16	---	---
Chlamydamonas	---	32	---	---
Chrysococcus	---	---	64	---
Euglena	---	---	64	---
Pandorina	---	---	64	---
Unidentified	512	448	1,600	768
Miscellaneous Ciliate	---	---	---	128
Total	2,694	1,376	6,790	1,997

Table B-2

Phytoplankton

Station 2 - Upper Des Moines River

(org/ml)

Species	June 17	July 8	August 13	September 9
Anabaena	-	-	-	6
Anacystis	-	-	-	6
Oscillatoria	-	-	13	38
Cyclotella	1664	496	3904	736
Melosira	-	304	448	-
Navicula	64	-	-	-
Nitzschia	448	16	1280	-
Unidentified	-	16	-	32
Actinastrum	64	-	-	-
Chlorella-like	-	-	64	-
Chroococcus	64	-	384	-
Coelastrum	-	16	64	-
Oocystis	64	-	-	-
Scenedesmus	256	16	128	32
Unidentified	64	-	-	32
Chlamydomonas	64	16	-	-
Chrysococcus	-	-	192	32
Euglena	64	-	-	32
Pandorina	-	-	-	64
Trachelomonas	-	-	64	-
Unidentified	1280	576	1408	992
Miscellaneous				
Ciliate	-	48	-	32
Total	4096	1504	7949	2034

Table B-3

Phytoplankton

Station 3 - Lower Avery Creek

(org/ml)

Species	June 17	July 8	August 13	September 9
Oscillatoria	-	-	-	6
Phormidium	-	-	6	-
Cyclotella	1920	384	960	992
Cymbella	-	-	64	-
Gyrosigma	-	-	128	-
Melosira	-	240	128	192
Meridion	-	16	64	-
Nitzschia	-	-	1088	96
Surirella	-	-	-	32
Synedra	-	16	-	-
Unidentified	-	-	128	32
Chlorella-like	-	-	192	-
Chroococcus	-	16	64	-
Coelastrum	128	32	-	-
Scenedesmus	192	48	-	64
Unidentified	64	32	-	-
Chlamydomonas	192	-	-	-
Chrysococcus	64	-	-	-
Euglena	256	-	256	-
Pandorina	-	-	64	-
Trachelomonas	64	-	-	32
Unidentified	1600	512	1408	992
Miscellaneous				
Ciliate	192	-	-	96
Codonella	-	-	128	-
Unidentified	64	16	-	-
Total	4736	1312	4678	2,534

Table B-4

Phytoplankton

Station 4 - Upper Avery Creek

(org/ml)

Species	June 17	July 8	August 13	September 9
Anacystis	-	-	6	-
Oscillatoria	-	-	6	-
Cyclotella	704	2394	1344	1376
Cymbella	-	-	64	-
Melosira	-	-	-	288
Navicula	-	-	128	-
Nitzschia	96	80	896	64
Unidentified	-	16	-	-
Ankistrodesmus	-	80	-	-
Chlorella-like	-	64	-	-
Chroococcus	-	16	-	32
Coelastrum	-	16	64	-
Oocystis	-	16	-	-
Scenedesmus	96	64	-	96
Tetraedron	-	-	64	-
Unidentified	96	80	-	32
Chlamydomonas	64	-	2112	64
Chrysococcus	-	48	896	32
Euglena	1152	432	1856	1696
Lepocinclis	-	16	-	32
Pandorina	-	16	192	-
Phacus	64	16	-	32
Peridinium	-	-	192	-
Trachelomonas	32	256	-	32
Unidentified	1372	912	2368	2080
Miscellaneous				
Ciliate	256	-	-	32
Codonella	-	-	-	32
Rotifer	-	16	-	-
Unidentified	-	32	-	-
Total	3936	4570	10188	5920

Table B-5

Zooplankton Analysis

Des Moines River and Avery Creek

	Station 1	Station 2	Station 3	Station 4
June 21*				
Cladocerans	16%	17%	4%	9%
Copepods	73%	80%	96%	82%
Rotifers	11%	3%	---	9%
July 17				
Cladocerans	3 org/l	3 org/l	3 org/l	1 org/l
Copepods	3 org/l	3 org/l	4 org/l	3 org/l
Rotifers	few present	few present	few present	few present
Sept. 27				
Cladocerans	2 org/100 l	6 org/100 l	----------	----------
Copepods	1 org/100 l	3 org/100 l	NA	NA
Rotifers	few present	few present	----------	----------

*Relative Abundance

Table B-6

Periphyton Analysis
June - July 1975

Species	Station 2	Station 3	Station 4
Actinastrum			x
Amoeba	x		
Anabaena	x		
Chlamydamonas			x
Chilodonella			x
Cladoceran			x
Closterium	x		x
Coelastrum	x		
Coleps	x		
Cosmarium	x	x	
Cymbella	x		x
Dictyosphaerium		x	
Euglena	x		
Frontania	x	x	
Gloecystis	x		
Gonphonema			x
Gyrosigma			x
Melosira	x	x	x
Microcystis	x	x	x
Microspora	x	x	x
Monas	x		
Navicula	x	x	x
Nostoc	x	x	x
Oocystis		x	x
Paramecuem	x		x
Phacus	x	x	x
Rotifer	x		x
Scenedesmus	x	x	x
Synedra	x		
Tribonema		x	
Ulothrix	x	x	x
Vorticulla	x	x	x
Ash free weight (gms/area slide)	0.024	0.020	0.034

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Table B-7

Water Quality Parameters

June 17, 1975

	Sta. 1 Lower Des Moines R.	Sta. 2 Upper Des Moines R.	Sta. 3 Lower Avery Creek	Sta. 4 Upper Avery Creek
pH	7.7	8.1	7.9	7.7
DO (mg/1)	7.7	7.9	7.7	9.0
Tot. Alk. (mg $CaCO_3$/1)	203	203	167	131
NO_3 (mg N/1)	7.5	6.9	4.5	0.4
NH_3 (mg N/1)	<0.04	0.04	<0.04	0.04
TOC (mg C/1)	7	9	9	11
Calcium (mg $CaCO_3$/1)	212	208	200	212
Orthophosphate (mg P/1)	0.21	0.15	0.08	0.02
Tot. Phosphate (mg P/1)	0.25	0.18	0.12	0.11
Sodium (mg Na/1)	8	9	13	20
Potassium (mg K/1)	2.3	1.8	3.2	6.0
Magnesium (mg Md/1)	25	25	24	18
Chloride (mg Cl^-/1)	18	17	15	9
Sulfate (mg SO_4^{-2}/1)	52	52	82	168
Silica (mg SiO_2/1)	9.1	9.2	7.8	4.3
Temperature °C	23.0	20.0	23.0	23.0
Total Dissolved Solids	460	460	550	470
Secchi Disc (meters)	0.50	0.25	0.25	0.25
Turbidity (JTU)	26	30	17	16
Specific Conductance	NA	NA	NA	NA
BOD_5 (mg/1)	1.6	1.5	2.5	5.3
Total Coliforms (org/100 ml)	800	300	900	4100
Fecal Coliforms (org/100 ml)	240	10	470	1900

Table B-8

Water Quality Parameters

July 8, 1975

	Sta. 1 Lower Des Moines R.	Sta. 2 Upper Des Moines R.	Sta. 3 Lower Avery Creek	Sta. 4 Upper Avery Creek
pH	7.9	7.9	7.9	7.8
DO (mg/l)	7.5	7.3	7.1	8.6
Tot. Alk. (mg CaCO$_3$/l)	195	195	194	167
NO$_3$ (mg N/l)	7.8	7.6	7.0	0.6
NH$_3$ (mg N/l)	0.04	0.06	<0.04	0.06
TOC (mg C/l)	9	5	7	16
Calcium (mg CaCO$_3$/l)	192	204	192	252
Orthophosphate (mg P/l)	0.11	0.12	0.11	0.01
Tot. Phosphate (mg P/l)	0.18	0.14	0.15	0.09
Sodium (mg Na/l)	7.5	8.0	9.2	2.0
Potassium (mg K/l)	2.7	2.7	2.9	7.8
Magnesium (mg Md/l)	22	22	23	22
Chloride (mg Cl$^-$/l)	16.0	17.0	17.0	11.0
Sulfate (mg SO$_4^{-2}$/l)	47	59	67	114
Silica (mg SiO$_2$/l)	7.5	7.9	9.5	1.2
Temperature ^{o}C	28.2	27.8	28.0	28.0
Total Dissolved Solids	430	410	380	540
Secchi Disc (meters)	0.25	0.25	0.30	0.25
Turbidity (JTU)	18	20	21	12
Specific Conductance	590	700	590	590
BOD$_5$ (mg/l)	3.8	3.4	3.1	8.2
Total Coliforms (org/100 ml)	200	400	600	1600
Fecal Coliforms (org/100 ml)	50	100	280	800

Table B-9

Water Quality Parameters

August 13, 1975

	Sta. 1 Lower Des Moines R.	Sta. 2 Upper Des Moines R.	Sta. 3 Lower Avery Creek	Sta. 4 Upper Avery Creek
pH	8.0	7.9	7.8	7.1
DO (mg/l)	6.6	6.6	5.3	8.0
Tot. Alk. (mg $CaCO_3$/l)	198	194	198	254
NO_3 (mg N/l)	0.85	0.82	0.80	0.05
NH_3 (mg N/l)	0.06	0.08	0.06	0.20
TOC (mg C/l)	11	11	9	23
Calcium (mg $CaCO_3$/l)	244	208	192	334
Orthophosphate (mg P/l)	0.12	0.14	0.35	0.16
Tot. Phosphate (mg P/l)	0.39	0.40	0.83	0.73
Sodium (mg Na/l)	NA	NA	NA	NA
Potassium (mg K/l)	NA	NA	NA	NA
Magnesium (mg Md/l)	17.4	22.3	24.3	25.7
Chloride (mg Cl^-/l)	24.0	24.0	23.0	9.5
Sulfate (mg SO_4^{-2}/l)	116	116	118	112
Silica (mg SiO_2/l)	4.9	4.9	4.8	3.4
Temperature °C	25.8	25.9	25.9	24.5
Total Dissolved Solids	450	420	430	560
Secchi Disc (meters)	NA	0.25	0.25	0.25
Turbidity (JTU)	15	18	16	18
Specific Conductance	590	578	590	788
BOD_5 (mg/l)	1.5	0.8	1.7	7.3
Total Coliforms (org/100 ml)	2000	3700	4300	3500
Fecal Coliforms (org/100 ml)	320	1300	2500	1300

Table B-10

Water Quality Parameters

September 9, 1975

	Sta. 1 Lower Des Moines R.	Sta. 2 Upper Des Moines R.	Sta. 3 Lower Avery Creek	Sta. 4 Upper Avery Creek
pH	8.1	8.0	8.0	6.8
DO (mg/1)	6.8	5.1	7.9	4.9
Tot. Alk. (mg $CaCO_3$/1)	142	144	139	68
NO_3 (mg N/1)	1.55	1.55	1.50	0.55
NH_3 (mg N/1)	0.02	0.01	0.04	0.50
TOC (mg C/1)	12	11	12	21
Calcium (mg $CaCO_3$/1)	160	144	144	236
Orthophosphate (mg P/1)	0.12	0.14	0.13	0.01
Tot. Phosphate (mg P/1)	0.16	0.21	0.18	0.13
Sodium (mg Na/1)	14	17	16	12
Potassium (mg K/1)	4.8	5.0	5.4	8.6
Magnesium (mg Md/1)	52	64	64	56
Chloride (mg Cl^-/1)	17.0	16.5	15.5	5.0
Sulfate (mg SO_4^{-2}/1)	68	85	80	220
Silica (mg SiO_2/1)	3.9	4.2	4.2	3.2
Temperature °C	22.6	21.8	21.8	21.0
Total Dissolved Solids	150	150	230	240
Secchi Disc (meters)	NA	NA	NA	NA
Turbidity (JTU)	39	42	40	34
Specific Conductance	407	395	407	577
BOD_5 (mg/1)	1.0	1.3	1.5	3.5
Total Coliforms (org/100 ml)	800	400	700	1700
Fecal Coliforms (org/100 ml)	560	340	800	1500

Table B-11

Pesticides

Des Moines River and Avery Creek
(Parts per trillion)

Station & Date	Heptachlor Epoxide	Heptachlor	Dieldrin	Aldrin
Station 1				
June 17	-	-	13.0	-
July 8	6.3	-	17.0	-
Aug. 13	-	-	8.0	-
Sept. 9	-	trace	11.0	-
Station 2				
June 17	-	-	13.0	-
July 8	6.9	-	18.0	-
Aug. 13	-	-	8.0	-
Sept. 9	-	-	7.0	-
Station 3				
June 17	-	5.5	13.0	-
July 8	-	-	16.0	-
Aug. 13	2.0	-	8.0	-
Sept. 9	-	-	10.0	-
Station 4				
June 17	-	4.9	11.0	-
July 8	-	-	13.0	-
Aug. 13	-	-	6.0	-
Sept. 9	7.0	-	8.0	trace

Table B-12

Metals (µg/l)

(Total metals in water)

Des Moines River and Avery Creek

Station and Date	Cd	Cn^{+6}	Cu	Fe*	Pb	Zn	Hg (ppb)
Station 1 (Lower Des Moines River Station near Chillicothe)							
June 17	<10	50	33	1.1	33	<10	NA
July 8	<10	35	<10	.65	<10	<10	0.25 ppb
Aug. 13	<10	<10	70	.48	44	15	0.40
Sept. 9	<10	<10	67	.25	19	15	NA
Station 2 (Upper Des Moines River Station Above Avery Creek)							
June 17	<10	41	30	.95	47	<10	NA
July 8	<10	49	<10	.65	<10	10	0.25 ppb
Aug. 13	<10	<10	17	.48	16	17	0.38
Sept. 9	<10	<10	12	.79	17	15	NA
Station 3 (Lower Avery Creek Station at Confluence with Des Moines River)							
June 17	<10	62	30	.77	52	<10	NA
July 8	<10	32	130	.77	<10	11	0.25 ppb
Aug. 13	<10	<10	10	.79	24	12	0.40
Sept. 9	<10	<10	12	.79	42	14	NA
Station 4 (Upper Avery Creek Station Near County Road Bridge)							
June 17	<10	50	33	.77	45	<10	NA
July 8	<10	40	<10	.65	<10	<10	0.25 ppb
Aug. 13	<10	<10	16	1.50	25	17	0.43
Sept. 9	<10	<10	12	1.85	36	12	NA

*mg/l

Table B-13

Macroinvertebrates

Des Moines River near Eddyville (Highway 137)

Organisms/meter^2

Organisms	July 2	August 1	August 30	September 26	October 24
Ephemeroptera					
Baetis sp.	155	2,153	1,021	49	100
Stenonema	22	---	127	250	1,909
Caenis	22	---	---	---	---
Isonychia	622	543	222	---	---
Diptera					
Simulidae	2,688	22	38	27	---
Empididae	200	27	11	---	---
Chironomidae	377	155	793	1,087	821
Trichoptera					
Hydropsyche sp.	2,397	3,633	1,887	815	1,370
Potamyia	21,511	3,146	3,596	9,351	1,276
Hydroptilidae	---	194	94	5	66
Cheumatopsyche	421	38	11	27	---
Leptocella	---	11	---	---	---
Psychomyiidae	---	---	11	22	5
Miscellaneous					
Coleoptera	---	5	---	---	---
Plecoptera	---	---	---	---	105
Odonata	---	---	---	---	---
Annelida	---	---	---	---	---
Acarina	---	5	---	---	5
Total	28,415	9,932	7,811	11,633	5,657

Source: Dr. W. B. Merkley, Drake University, 1975.

Table B-14

Macroinvertebrates

Des Moines River at Chillicothe Bridge

Organisms/meter^2

Organisms	July 2	August 1	August 30	September 26	October 24
Ephemeroptera					
Baetis sp.	66	44	138	16	---
Stenonema	5	---	33	16	1,276
Caenis	11	---	---	16	---
Isonychia	155	50	88	49	111
Diptera					
Simulidae	260	5	11	5	---
Empididae	---	---	---	16	---
Chironomidae	327	50	155	122	1,115
Trichoptera					
Hydropsyche sp.	2,958	2,824	2,059	649	593
Potamyia	11,888	1,942	2,713	5,555	1,687
Hydroptilidae	5	22	5	---	---
Chematopsyche	38	---	11	22	27
Leptocella	---	---	---	22	---
Psychomyiidae	---	---	22	38	77
Miscellaneous					
Coleoptera	---	---	---	---	---
Plecoptera	---	---	---	---	138
Odonata	---	---	---	---	---
Annelida	---	---	---	---	---
Acarina	---	---	---	---	---
Total	15,713	4,937	5,235	6,526	5,024

Source: Dr. W. B. Merkley, Drake University, 1975.

Table B-15

Macroinvertebrates

Avery Creek Near County Road Bridge

Organisms/meter^2

Organisms	July 2	August 1	August 30	September 26	October 24
Ephemeroptera					
Baetis sp.	---	5	27	---	---
Stenonema	38	---	---	---	5
Caenis	27	---	---	---	---
Isonychia	---	---	---	---	---
Diptera					
Simulidae	55	---	---	---	---
Empididae	---	---	---	---	---
Chironomidae	782	27,217	20,712	14,446	4,512
Trichoptera					
Hydropsyche sp.	5	22	11	---	---
Potamyia	44	172	133	22	5
Hydroptilidae	---	---	---	---	---
Cheumatopsyche	5	---	---	---	---
Leptocella	---	---	---	---	---
Psychomyiidae	---	---	---	---	---
Miscellaneous					
Coleoptera	---	5	---	---	---
Plecoptera	---	---	---	---	---
Odonata	---	---	11	11	5
Annelida	---	155	---	---	---
Acarina	---	---	---	---	---
Total	956	27,576	20,894	14,479	4,527

Source: Dr. W. B. Merkley, Drake University, 1975.

Table B-16

Macroinvertebrates

Pond Samples within Project Site

Organisms/meter^2

Organisms	July 2	August 1	August 30	September 26	October 24
Ephemeroptera					
Caenis	2	---	---	---	---
Hexagenia	21	78	26	2	---
Diptera					
Chironomidae	271	209	144	450	78
Coleoptera					
Gyrinidae	---	2	1	1	---
Haliplidae	1	5	1	---	---
Odonata					
Anisoptera	9	4	11	27	17
Zygoptera	2	23	4	22	51
Annelida					
Lumbricidae	4	3	2	4	3
Hemiptera					
Notonectidae	2	---	3	---	---
Corixidae	6	11	13	2	---
Ranatra	---	2	2	4	---
Amphipoda					
Hyallela	3	7	16	5	105
Mollusca					
Physa	16	23	12	14	58
Total	337	367	235	531	312

Source: Dr. W. B. Merkley, Drake University, 1975.

Table B-17

Macroinvertebrates

Organisms in drift at Eddyville (Highway 137)

Numbers/hour per 15.5 ft^3/sec.*

Organisms	July 2	August 1	August 30	September 26	October 24
Ephemeroptera					
Baetis sp.	6	---	---	14	---
Stenonema	20	20	6	14	2
Caenis	---	2	10	---	---
Isonychia	---	8	6	---	2
Diptera					
Simulidae	3	---	---	---	2
Empididae	---	5	---	14	2
Chironomidae	30	215	97	113	9
Trichoptera					
Hydropsyche sp.	200	442	1,065	155	45
Potamyia	23	32	26	98	7
Hydroptilidae	---	---	---	---	---
Cheumatopsyche	---	55	136	---	7
Leptocella	---	---	---	---	---
Psychomyiidae	---	---	---	---	---
Miscellaneous					
Coleoptera	---	7	10	---	---
Plecoptera	---	---	---	---	---
Odonata	---	---	---	---	---
Annelida	---	---	---	---	---
Acarina	---	---	---	---	---
Total	282	786	1,356	408	76

* 15.5 ft^3/sec. is maximum volume of make-up water required for proposed project.

Source: Dr. W. B. Markley, Drake University, 1975.

LIST OF FIGURES

Figure No.

B-1 Current Profile - Des Moines River Average Flow vs Distance Along Transect Section 1

B-2 Current Profile - Des Moines River Average Flow vs Distance Along Transect Section 2

B-3 Current Profile - Des Moines River Average Flow vs Distance Along Transect Section 3

B-4 Current Profile - Des Moines River Average Flow vs Distance Along Transect Section 4

B-5 Current Profile - Des Moines River Average Flow vs Distance Along Transect Section 5

B-6 Current Profile - Des Moines River Average Flow vs Distance Along Transect Section 6

B-7 Depth Profile - Des Moines River Section 1

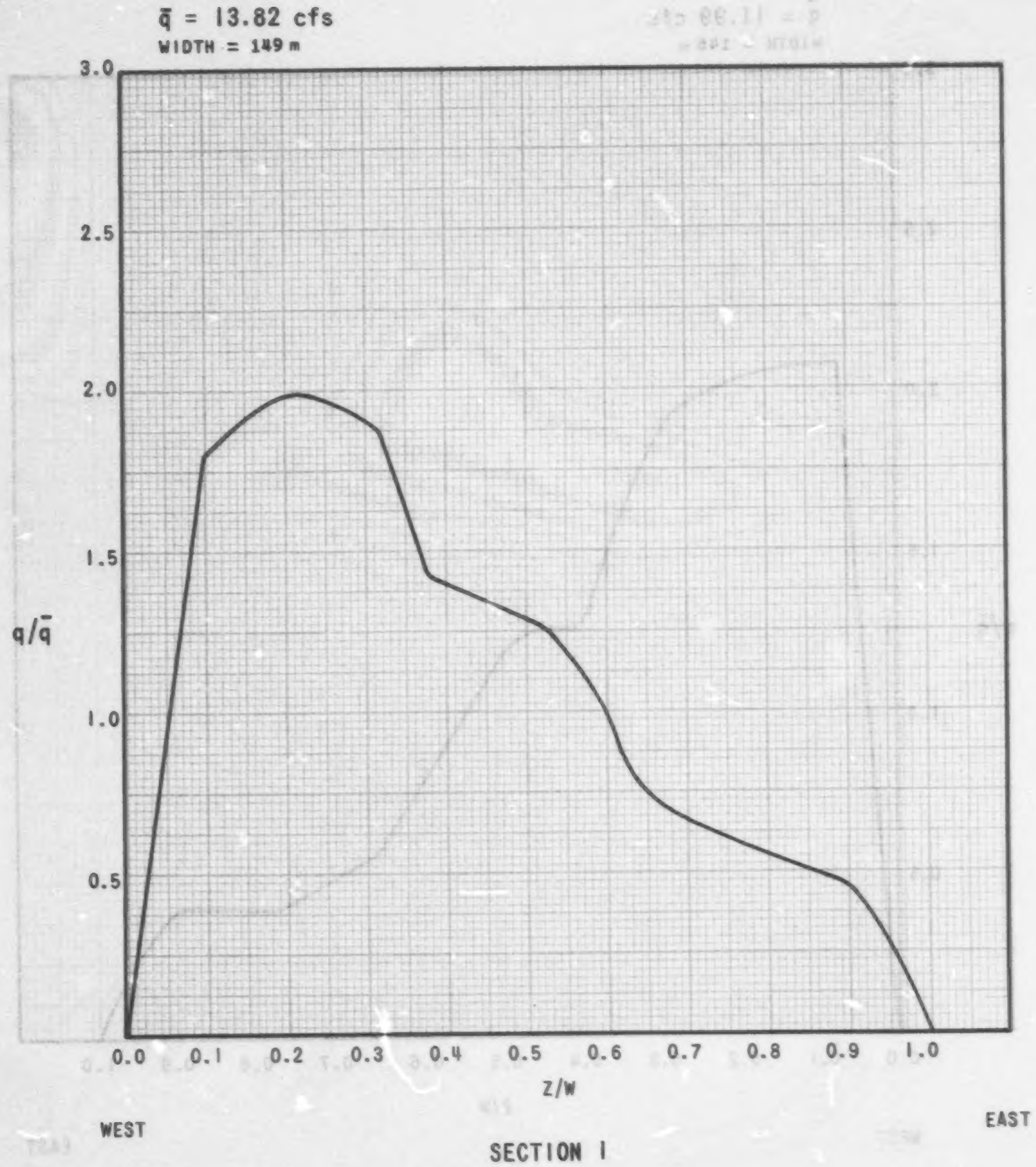
B-8 Depth Profile - Des Moines River Section 2

B-9 Depth Profile - Des Moines River Section 3

B-10 Depth Profile - Des Moines River Section 4

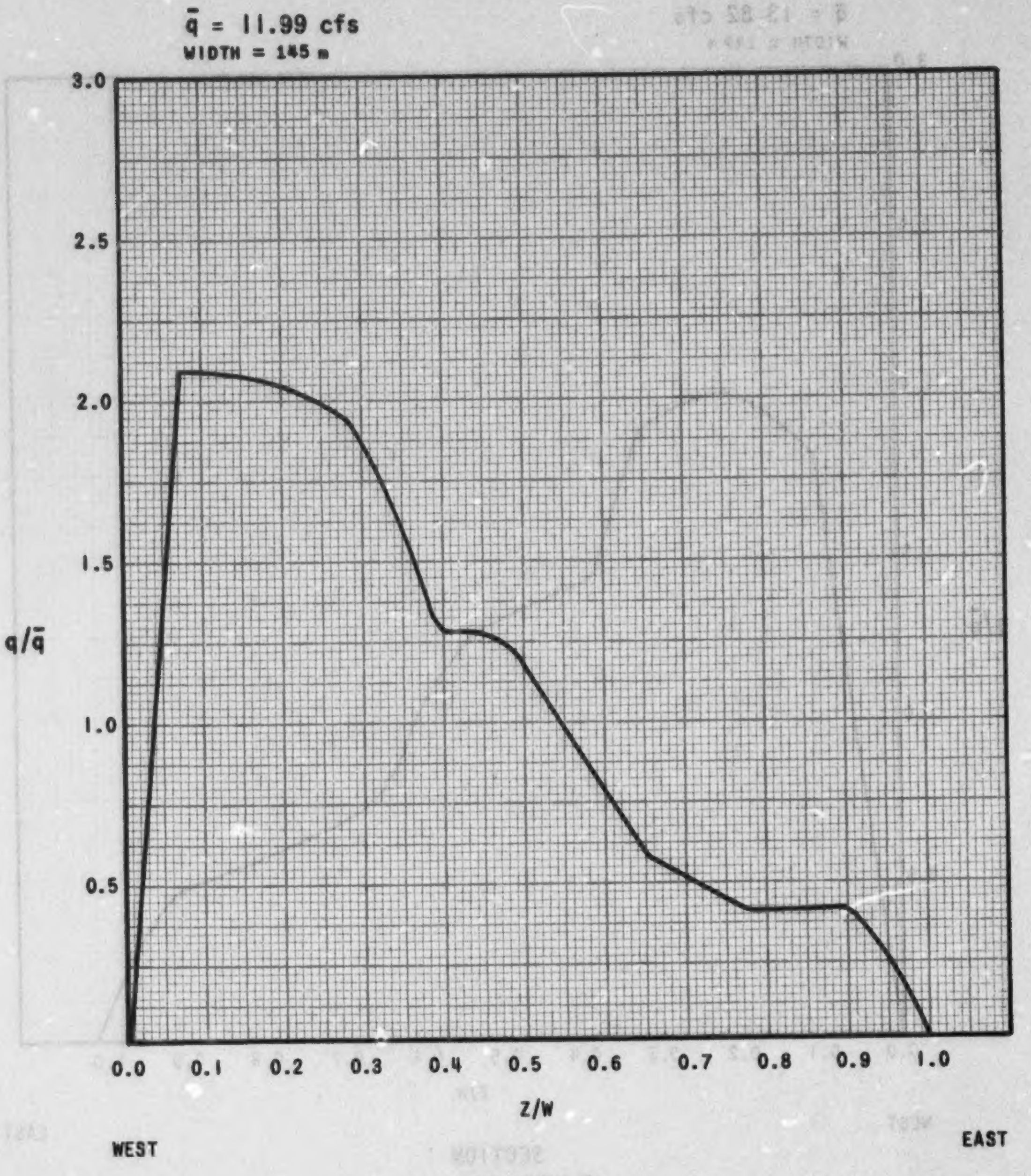
B-11 Depth Profile - Des Moines River Section 5

B-12 Depth Profile - Des Moines River Section 6



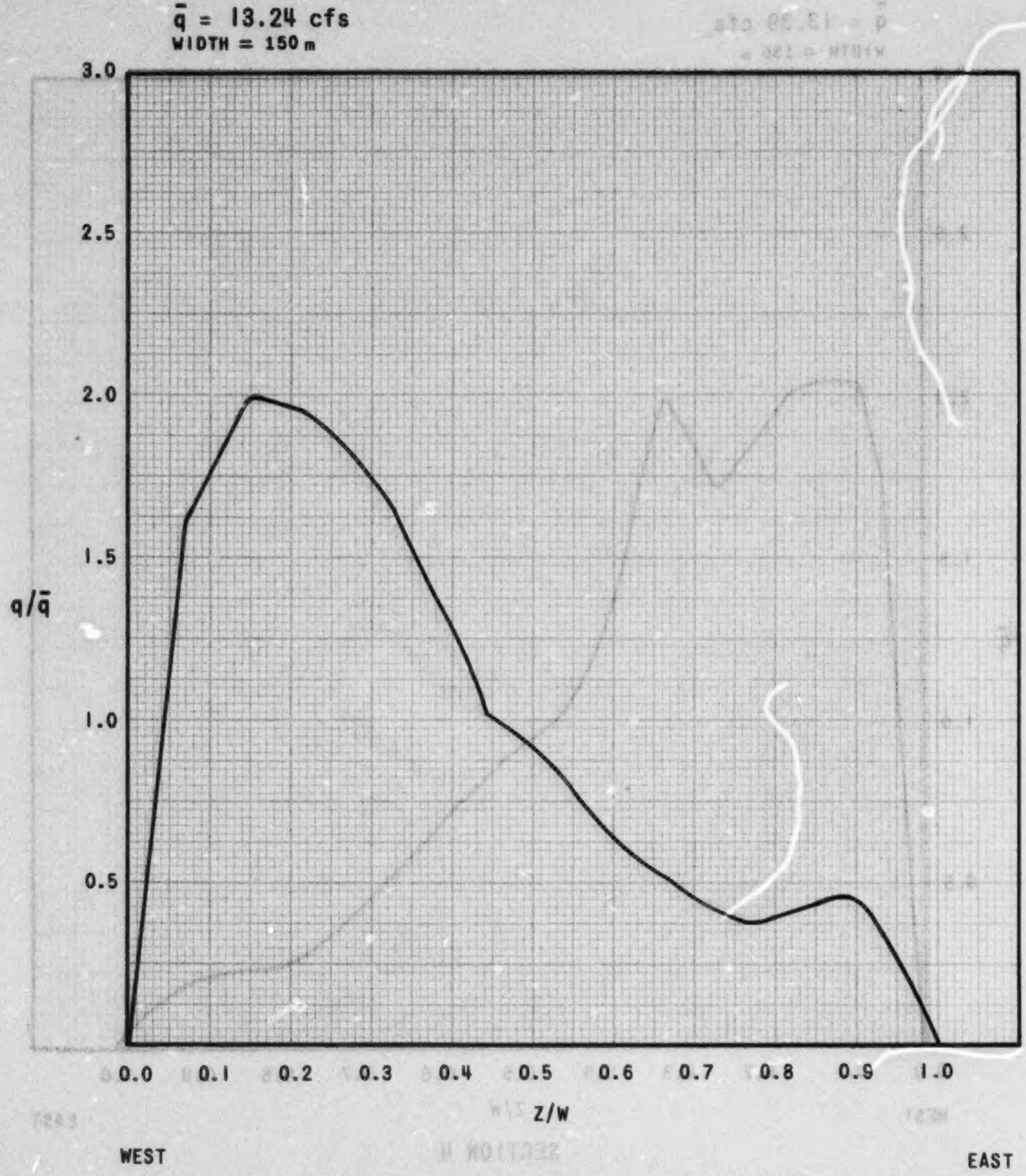
SECTION I

CURRENT PROFILE--DES MOINES RIVER



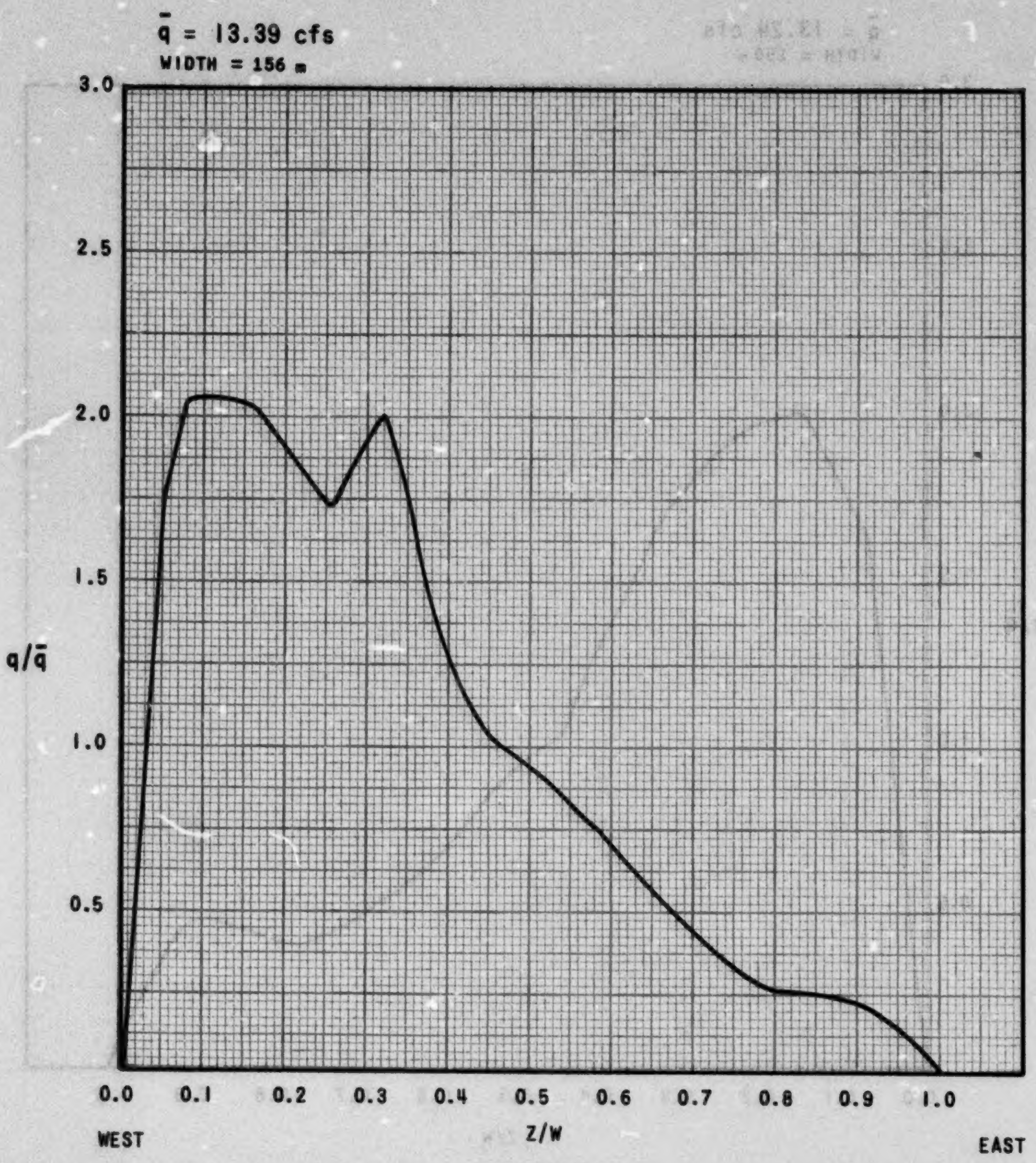
SECTION 3

CURRENT PROFILE--DES MOINES RIVER



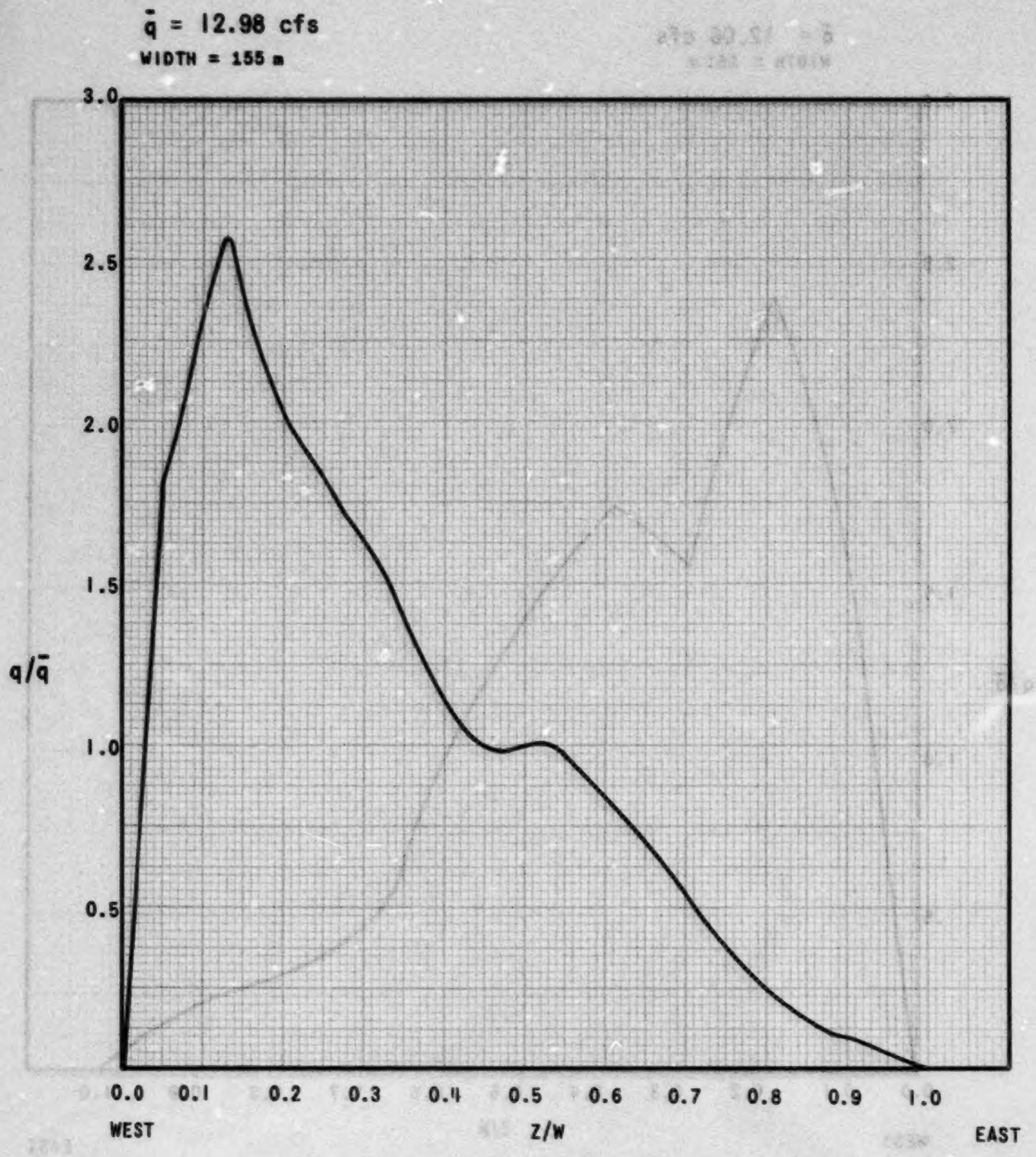
SECTION 2

CURRENT PROFILE--DES MOINES RIVER



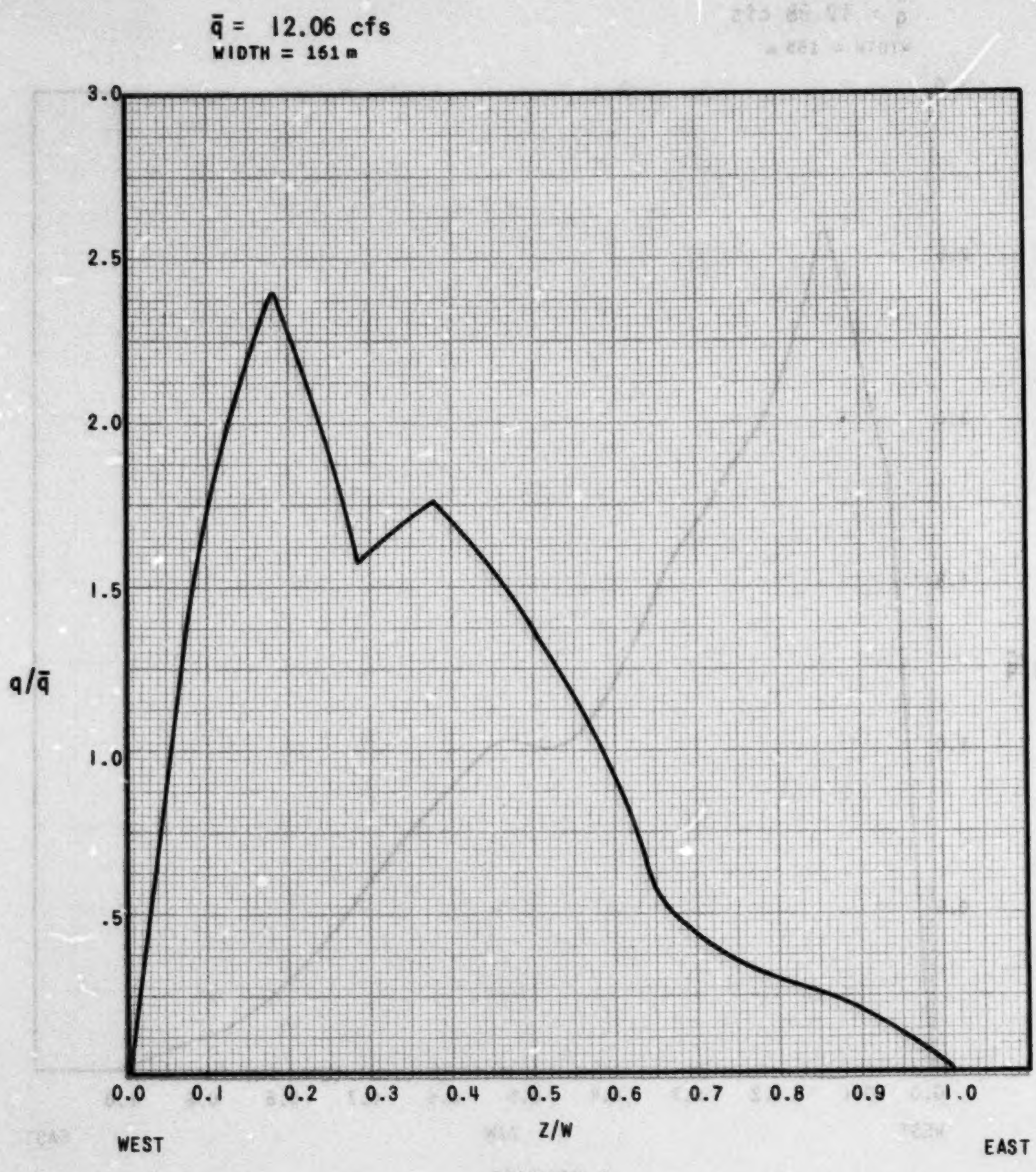
SECTION 4

CURRENT PROFILE--DES MOINES RIVER



SECTION 5

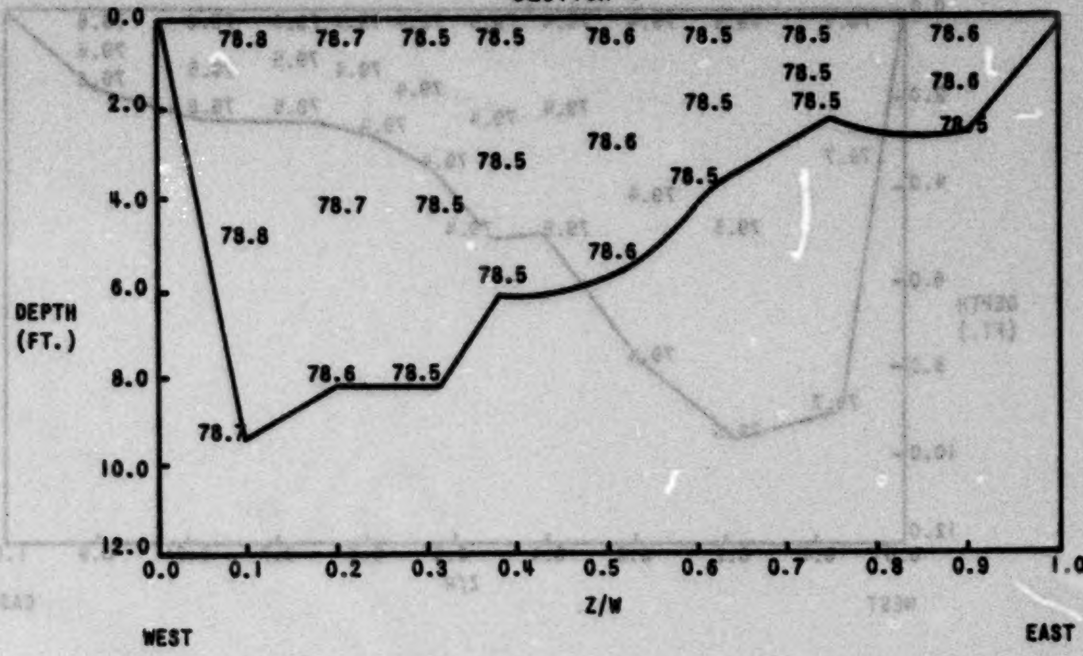
CURRENT PROFILE--DES MOINES RIVER



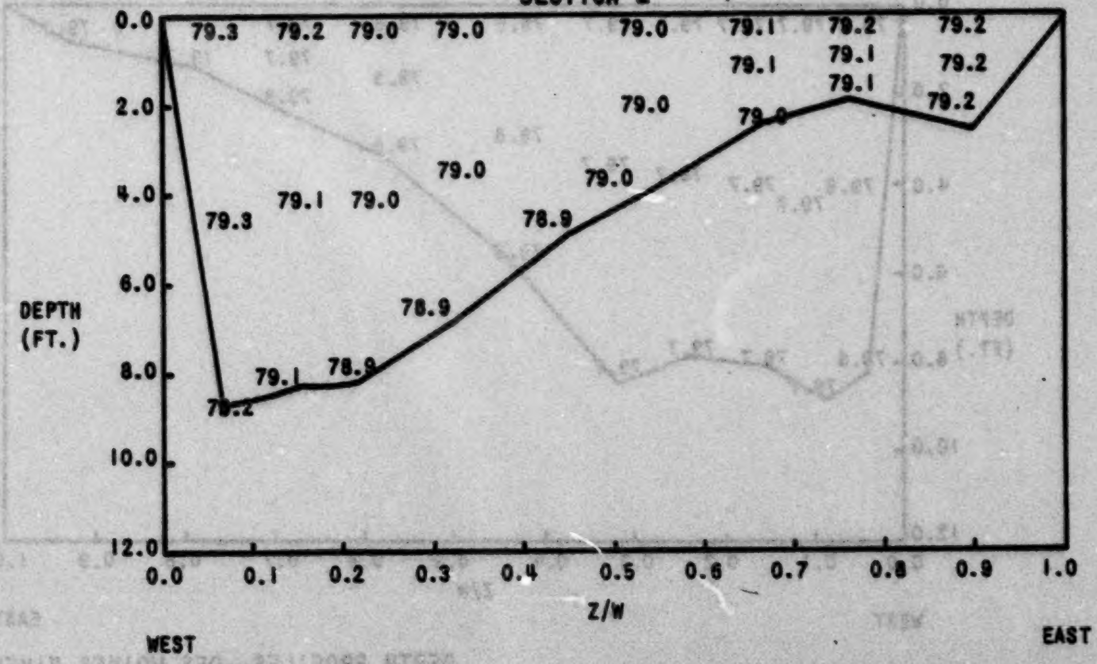
SECTION 6

CURRENT PROFILE--DES MOINES RIVER

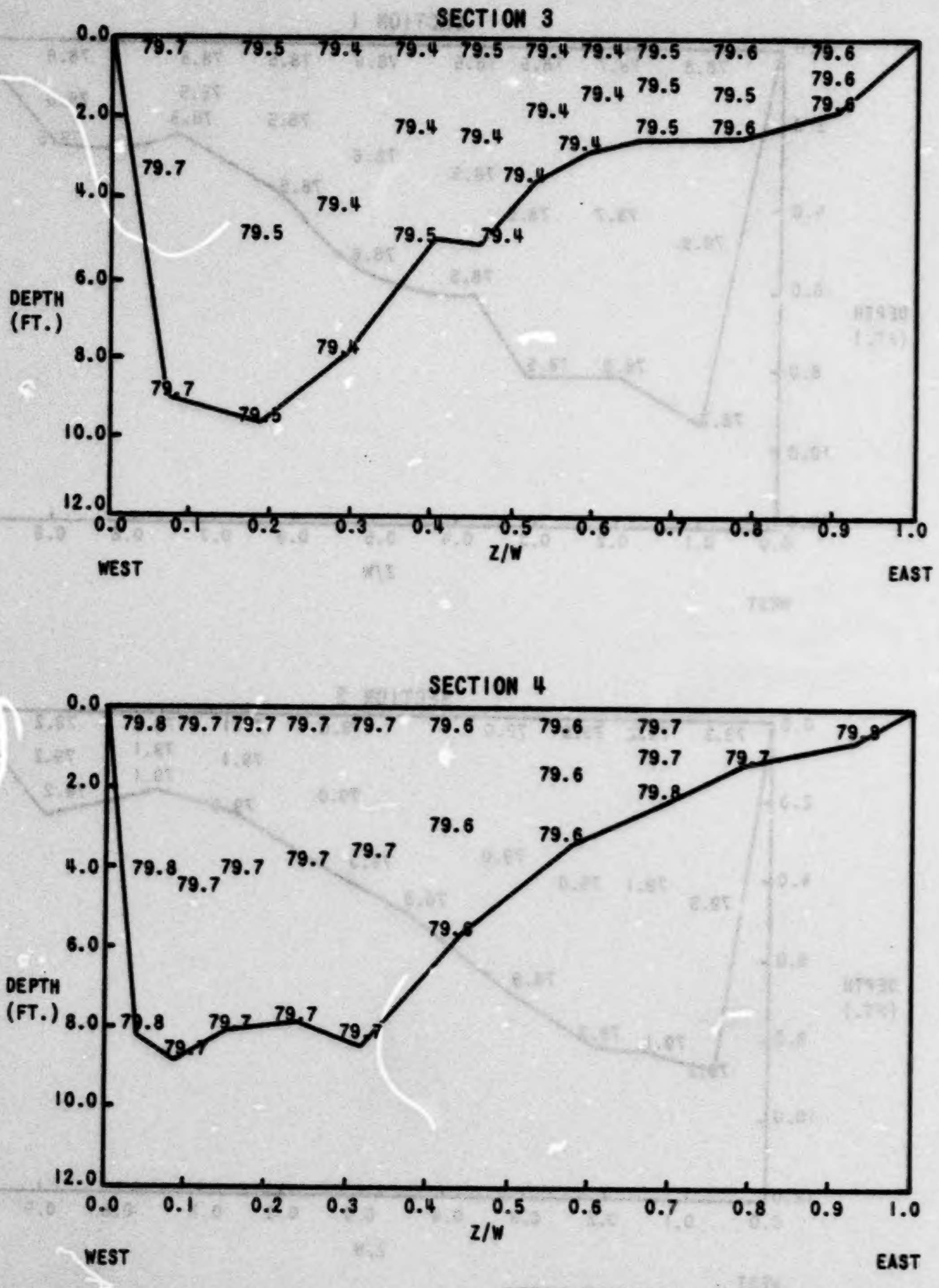
SECTION 1



SECTION 2



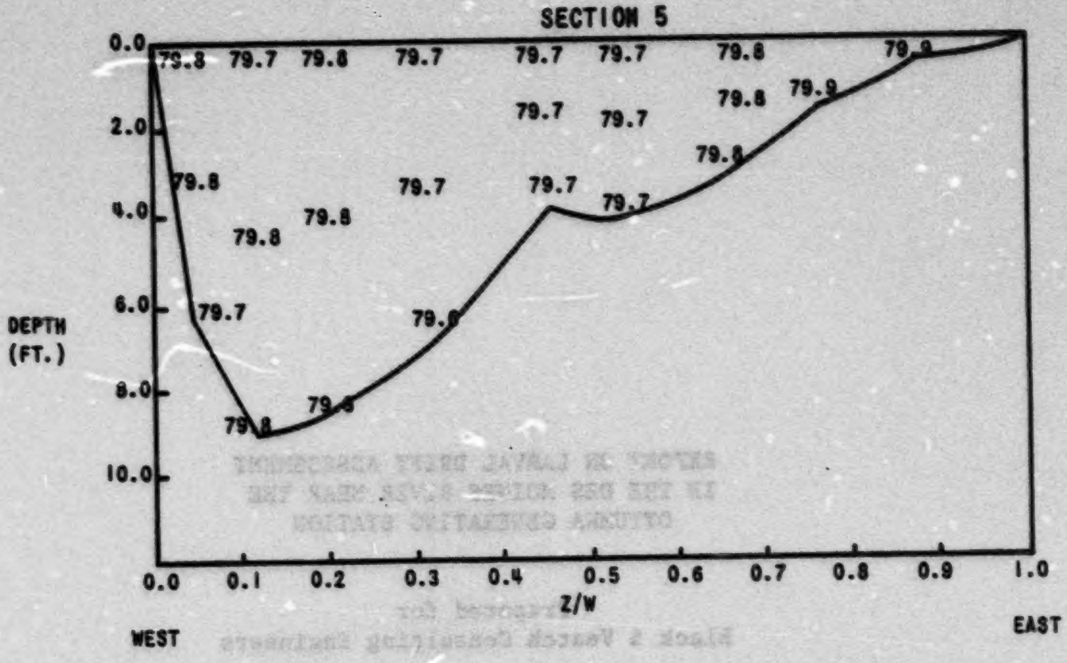
DEPTH PROFILES--DES MOINES RIVER

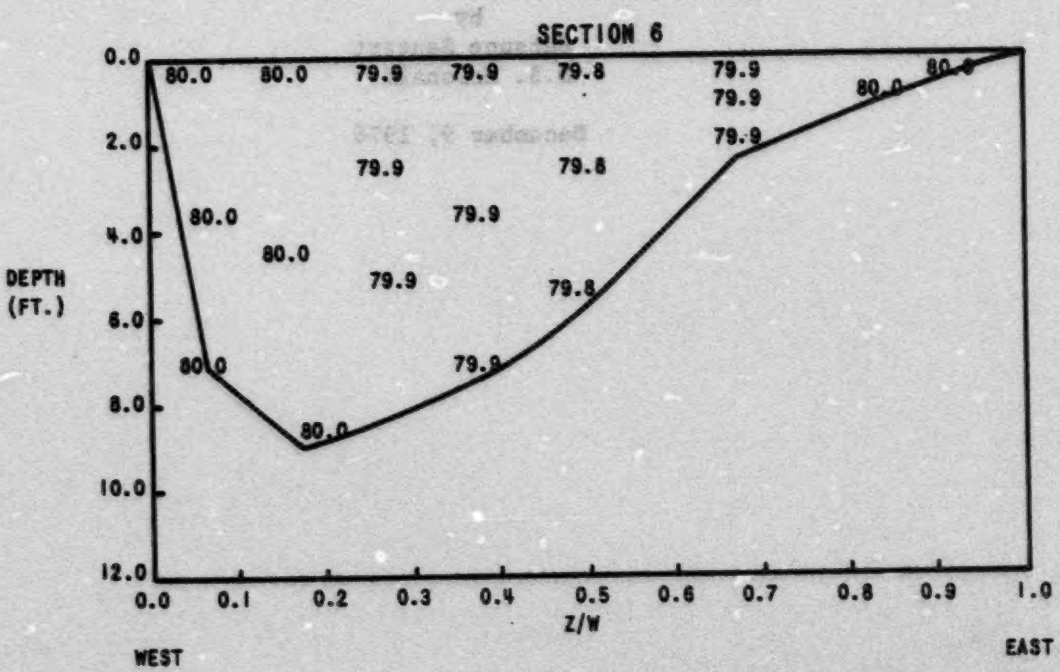


SECTION 3

SECTION 4

DEPTH PROFILES--DES MOINES RIVER





DEPTH PROFILES--DES MOINES RIVER

REPORT ON LARVAL DRIFT ASSESSMENT IN THE DES MOINES RIVER NEAR THE OTTUMWA GENERATING STATION

Prepared for
Black & Veatch Consulting Engineers

by
Suzanne Bangert
D.B. McDonald

December 9, 1976

INTRODUCTION

Larval drift studies were conducted on the Des Moines River north of Chillicothe, Iowa from May 1, 1976 to August 9, 1976. These studies were initiated in order to determine the extent of larval drift in the vicinity of the proposed make up water intake structure for the Ottumwa Generating Station.

METHODS

Three sampling stations were established approximately 500 feet upstream from the proposed intake structure, as shown in Figure 1. Vertical transects were made at Stations 1 and 3 on the west and east banks of the river. Both surface and bottom samples were taken. Due to high velocities, difficulties encountered while maneuvering the boat with the nets in tow, and the amount of sand collected in the samples, only surface samples were collected at Station 2 in mid-river.

Samples were collected in two Wildco Stream Drift Nets and buckets, with frame sizes of 12 x 18 inches and mesh size of 363 microns. These nets were attached to a mobile, light weight steel frame as shown in Figures 2 and 3. Detachable weights and floats enabled surface and bottom sampling.

During sample collection at Stations 1 and 3 the boat was anchored and velocities were determined at the surface and bottom depths utilizing a Price AA current meter. The velocity readings were then used in the following equation to determine the time interval required for 50 cubic meters of water (m^3) to pass through each net:

$$\text{Volume} = (\text{Set time, sec})(\text{velocity, fps})(1.5\ ft^2)(28.32\ l/ft^3)(1\ m^3/1000\ l)$$

where: Volume = 50 m^3 of water passing through the net
Set time = time interval the nets are kept in the water
Velocity = velocity at each sampling station
1.5 ft^2 = inlet area of the net (12" x 18"/144 in^2/ft^2)

The nets were placed in the water for the time intervals calculated. This

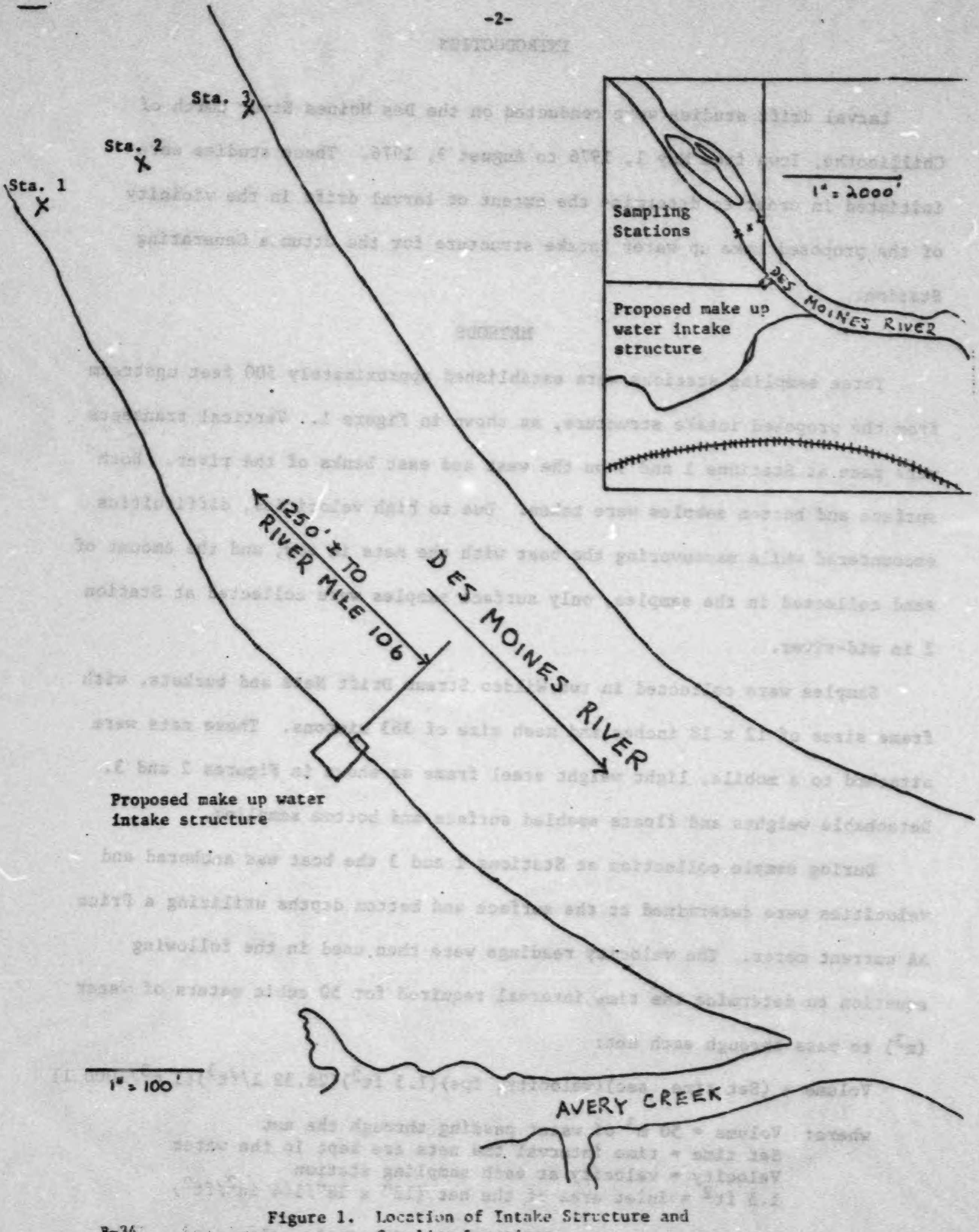

Sta. 3
Sta. 2
Sta. 1
Sampling Stations
1" = 2000'
DES MOINES RIVER
Proposed make up water intake structure
1250' ± TO RIVER MILE 106
DES MOINES RIVER
Proposed make up water intake structure
1" = 100'
AVERY CREEK

Figure 1. Location of Intake Structure and Sampling Locations.

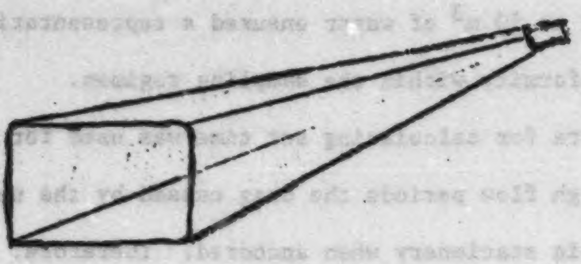


Figure 2. Wildco Stream Drift Net

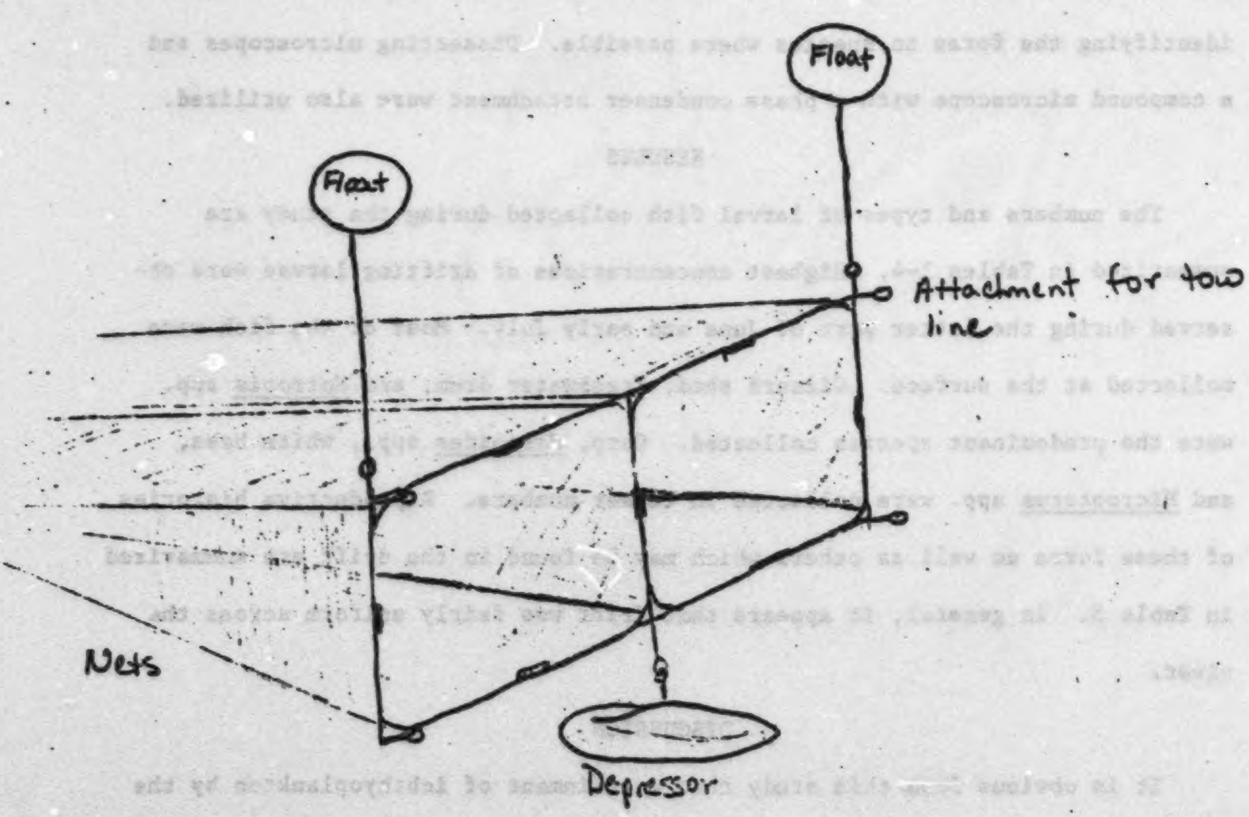


Figure 3. Frame Apparatus for towing or setting the drift nets

restriction of volume to 50 m^3 of water ensured a representative sampling volume as well as uniformity within the sampling regimen.

The same procedure for calculating set time was used for Station 2 with one variation. At high flow periods the drag caused by the nets was such that the boat did not remain stationary when anchored. Therefore, the boat was kept as stationary as possible by running the boat upstream against the current while determining velocity and placing the nets in the water for the appropriate time period.

All samples were preserved in 10% formalin and transferred to the Water Laboratory, University of Iowa, for analysis. Larval and juvenile fishwere removed from each sample and placed in labelled vials containing 5% formalin for taxonomic classification. Classification of the ichthyoplankton was completed with the aid of all of the references found at the end of this report, identifying the forms to species where possible. Dissecting microscopes and a compound microscope with a phase condenser attachment were also utilized.

RESULTS

The numbers and types of larval fish collected during the study are summarized in Tables 1-4. Highest concentrations of drifting larvae were observed during the latter part of June and early July. Most of the fish were collected at the surface. Gizzard shad, freshwater drum, and Notropis spp. were the predominant species collected. Carp, Carpoides spp., white bass, and Micropterus spp. were collected in lesser numbers. Reproductive histories of these forms as well as others which may be found in the drift are summarized in Table 5. In general, it appears that drift was fairly uniform across the river.

DISCUSSION

It is obvious from this study that entrainment of ichthyoplankton by the Ottumwa Generating Station cooling water system will not be a significant problem.

The majority of drift in the study occurred during high flow periods as indicated in Tables 1 and 5.

During the month of June when maximum concentrations of larval fish were collected (69% of the May 1 - August 9, 1976 total), the mean discharge in the Des Moines River was 12,400 cfs as recorded during the 1970-1975 period (Table 5). Since maximum make up water intake is 15.5 cfs, a maximum of 0.13% of the river volume and of the June larval drift would be entrained by the plant, assuming uniform distribution of the drift in the river. During the 1970-1975 record period, the lowest daily flow reported in June was 2,400 cfs while the lowest daily flow recorded for June 1976 was 3,570 cfs. Assuming a flow of 2,400 cfs during June, again less than 1% of the river volume will be utilized by the plant's cooling water system. Even at extremely low flow periods of 300 cfs, entrainment should be insignificant. Under these most adverse conditions only 5.2% of the river flow will be used for make up water and therefore a maximum of 5.2% of the drift would be entrained. Again, this is assuming a uniform distribution of drifting larvae in the river.

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Table 1. Numbers of Larval Fish Collected in Each Sample

Date	Station	Vol. through net		Number larval fish collected	Comments
		(m^3)	(ft^3)		
May 1, 1976	1 top sample A			0	Inventory sample to determine if drift occurring in area. River Temp = 17°C Mean Discharge:* 17,200 cfs
	B			0	
	1 bottom sample A			0	
	B			0	
May 7, 1976	1 top sample A	49	1730	0	Net caught on the motor at station 2 ∴ only one sample was taken at 2 bottom and at 3 top and bottom. River Temp = Unknown Mean Discharge: 14,800 cfs
	B			0	
	1 bottom sample A	50	1766	0	
	B			0	
	2 top sample A	48	1695	0	
	B			0	
	2 bottom sample A	52	1836	0	
	3 top sample A	52	1836	0	
	3 bottom sample A	52	1836	0	
May 20, 1976	1 top sample A	50	1766	4	River Temp = Unknown Mean Discharge: 12,900 cfs
	B			1	
	1 bottom sample A	49	1730	0	
	B			1	
	2 top sample A	51	1801	0	
	B			0	
	2 bottom sample A	33	1165	0	
	B			0	
	3 top sample A	50	1766	0	
	B			0	
	3 bottom sample A	48	1695	0	
	B			0	
June 5, 1976	1 top sample A	57	2013	2	River down approximately 5 feet since beginning of study. River Temp = 24°C Mean Discharge: 6,470 cfs
	B			0	
	1 bottom sample A	52	1836	0	
	B			1	
	2 top sample A	50	1766	0	
	B			0	
	3 top sample A	49	1730	3	
	B			8	
	3 bottom sample A	50	1766	0	
	B			0	
June 17, 1976	1 top sample A	51	1801	29	River Temp = 25°C Mean Discharge: 14,700 cfs
	B			9	
	1 bottom sample A	50	1766	6	
	B			7	
	2 top sample A	52	1836	26	
	B			69	
	3 top sample A	49	1730	34	
	B			59	
	3 bottom sample A	48	1695	4	
	B			2	

*Mean Discharge: Recorded daily at Ottumwa, Iowa by U. S. Geological Survey.

Table 1 continued

Date	Station	Vol. through net (m^3)	Vol. through net (ft^3)	Number larval fish collected	Comments
July 1, 1976	1 top sample A	51	1801	24	River down about 1-2 feet from previous sampling run. River Temp = 21°C Mean Discharge: 9,030 cfs
	B			16	
	1 bottom sample A	51	1801	0	
	B			0	
	2 top sample A	50	1766	1	
	B			1	
	3 top sample A	49	1730	18	
	B			18	
	3 bottom sample A	50	1766	0	
	B			3	
July 19, 1976	1 top sample A	52	1836	5	River down 10-15 feet since beginning of study. Since the water was so shallow (3 feet deep at stations 1 & 3 and 1½ feet deep at station 2), only top samples were taken at stations 1 and 2. River Temp = 28°C Mean Discharge: 918 cfs
	B			12	
	1 bottom sample A			no sample	
	B				
	2 top sample A	51	1801	4	
	B			3	
	3 top sample A	50	1766	3	
	B			3	
	3 bottom sample A			no sample	
	B				
Aug. 9, 1976	Mouth of Avery Creek to proposed intake structure site (top) sample A	42	1483	0	Water was extremely shallow, station 1 being non-existant (sandbar only). Tows were made due to low velocity conditions immediately below station 1. Water was only 6" deep at station 2 ∴ no samples were collected.
	B			0	
	From proposed intake site to station 1 (top) sample A	8	283	1	
	B			0	
	3 top sample A	51	1801	0	Normal set except water only 3 ft. deep∴only on set of samples collected. River temp = 26°C, Mean Discharge: 890 cfs
	B			0	

Table 2. Species Identification

Station 1

SURFACE				BOTTOM			
Sample A		Sample B		Sample A		Sample B	
Species	Length (mm)	Species	Length (mm)	Species	Length (mm)	Species	Length (mm)
			May 20, 1976				
Notropis	9	White Bass	7	0		Carpoides spp.	7
Notropis	8						
Notropis	6						
Notropis	10		June 5, 1976				
Gizzard Shad	13			0		Unidentified	11
Carpoides spp.	7						
			June 17, 1976				
Gizzard Shad	7	Gizzard Shad	9	Gizzard Shad	10.5	Gizzard Shad	6.5
Gizzard Shad	7	Gizzard Shad	8	Gizzard Shad	8	Gizzard Shad	6.5
Gizzard Shad	7.5	Gizzard Shad	7	Gizzard Shad	8	Gizzard Shad	7
Gizzard Shad	7.5	Gizzard Shad	7	Freshwater Drum	5.5	Gizzard Shad	8
Gizzard Shad	8	Gizzard Shad	9	Unidentified	4	Freshwater Drum	8
Gizzard Shad	7	Freshwater Drum	15	Unidentified	7.5	Freshwater Drum	12
Gizzard Shad	8	Freshwater Drum	8			Carp	8.5
Gizzard Shad	10	Notropis	5				
Gizzard Shad	8.5	Unidentified	5				
Gizzard Shad	5						
Gizzard Shad	7						
Gizzard Shad	7						
Gizzard Shad	18						
Gizzard Shad	16						
Freshwater Drum	13						
Freshwater Drum	6.5						
Freshwater Drum	9						
Freshwater Drum	6.5						
Freshwater Drum	6.5						
Freshwater Drum	6.5						
Freshwater Drum	8						
Freshwater Drum	4						
Freshwater Drum	6						
Freshwater Drum	6						
Freshwater Drum	5						
Freshwater Drum	5						
Notropis	5						

Table 2 continued

SURFACE				BOTTOM			
Sample A		Sample B		Sample A		Sample B	
Species	Length (mm)	Species	Length (mm)	Species	Length (mm)	Species	Length (mm)
			June 17, 1976 continued				
Notropis	5						
Notropis	5						
Unidentified	5						
			July 1, 1976				
Gizzard Shad	10	Gizzard Shad	10	0		0	
Gizzard Shad	9.5	Gizzard Shad	8				
Gizzard Shad	11.5	Gizzard Shad	12				
Gizzard Shad	12	Gizzard Shad	10				
Gizzard Shad	9.5	Gizzard Shad	7				
Gizzard Shad	9.5	Gizzard Shad	10				
Gizzard Shad	9.5	Gizzard Shad	9				
Gizzard Shad	9	Gizzard Shad	8.5				
Gizzard Shad	9	Gizzard Shad	8				
Gizzard Shad	9	Gizzard Shad	13				
Gizzard Shad	10	Gizzard Shad	13				
Gizzard Shad	9.5	Gizzard Shad	10				
Gizzard Shad	12.5	Gizzard Shad	6				
Gizzard Shad	9.5	Freshwater Drum	5				
Gizzard Shad	12	Freshwater Drum	7				
Gizzard Shad	8	Freshwater Drum	7				
Gizzard Shad	9	Freshwater Drum	15				
Gizzard Shad	8	Carpoides spp.	9				
Gizzard Shad	9						
Freshwater Drum	17.5	Unidentified	4				
Freshwater Drum	7.5						
Freshwater Drum	7						
Notropis	6.5						
Notropis	8		July 19, 1976				
Gizzard Shad	10	Gizzard Shad	10	No Sample		No Sample	
Gizzard Shad	10.5	Gizzard Shad	9				
Gizzard Shad	11	Gizzard Shad	9.5				

Table 2 continued

SURFACE				BOTTOM			
Sample A		Sample B		Sample A		Sample B	
Species	Length (mm)	Species	Length (mm)	Species	Length (mm)	Species	Length (mm)
July 19, 1976 continued							
Gizzard Shad	11	Gizzard Shad	9				
Notropis	5.5	Gizzard Shad	12				
		Gizzard Shad	9				
		Gizzard Shad	13				
		Gizzard Shad	12				
		Gizzard Shad	10.5				
		Gizzard Shad	10				
		Unidentified	4				
		Unidentified	4.5				
August 9, 1976							
INTAKE STRUCTURE SITE TO STATION 1, SURFACE SAMPLE							
Unidentified	4						

Unidentified = Due to damaged conditon

Table 3. Species Identification

Station 2

SURFACE				BOTTOM			
Sample A		Sample B		Sample A		Sample B	
Species	Length (mm)	Species	Length (mm)	Species	Length (mm)	Species	Length (mm)
			June 17, 1976				
Gizzard Shad	33	Gizzard Shad	35	No Sample		No Sample	
Gizzard Shad	25	Gizzard Shad	26				
Gizzard Shad	25	Gizzard Shad	30				
Gizzard Shad	33	Gizzard Shad	31				
Gizzard Shad	25	Gizzard Shad	25				
Gizzard Shad	24	Gizzard Shad	27				
Gizzard Shad	15	Gizzard Shad	9				
Gizzard Shad	17.5	Gizzard Shad	17				
Gizzard Shad	17.5	Gizzard Shad	9				
Gizzard Shad	19	Gizzard Shad	12				
Gizzard Shad	18	Gizzard Shad	10.5				
Gizzard Shad	14.5	Gizzard Shad	22				
Gizzard Shad	17.5	Gizzard Shad	17				
Gizzard Shad	17.5	Gizzard Shad	15				
Gizzard Shad	20	Gizzard Shad	12.5				
Gizzard Shad	19	Gizzard Shad	14				
Gizzard Shad	7	Gizzard Shad	10				
Gizzard Shad	11	Gizzard Shad	6.5				
Gizzard Shad	7.5	Freshwater Drum	10.5				
Gizzard Shad	8	Freshwater Drum	9				
Gizzard Shad	8	Freshwater Drum	7				
Gizzard Shad	8	White Bass	22				
Gizzard Shad	8	White Bass	23				
Gizzard Shad	8	Carpoides spp.	8				
Gizzard Shad	8.5	Carp	21.5				
Gizzard Shad	8	Unidentified	4				
Gizzard Shad	8.5						
Gizzard Shad	8						
Gizzard Shad	8.5						
Gizzard Shad	9						
Gizzard Shad	8.5						
Gizzard Shad	8						
Gizzard Shad	8						
Gizzard Shad	13.5						
Gizzard Shad	15						
Gizzard Shad	9						

Table 3 continued

SURFACE				BOTTOM			
Sample A		Sample B		Sample A		Sample B	
Species	Length (mm)	Species	Length (mm)	Species	Length (mm)	Species	Length (mm)
			June 17, 1976 continued				
Gizzard Shad	9			No sample		No Sample	
Gizzard Shad	9						
Gizzard Shad	8						
Gizzard Shad	8						
Gizzard Shad	9						
Gizzard Shad	8						
Gizzard Shad	8						
Gizzard Shad	9						
Gizzard Shad	8						
Gizzard Shad	8						
Freshwater Drum	24						
Freshwater Drum	9						
Freshwater Drum	5						
Freshwater Drum	7						
Freshwater Drum	6						
Freshwater Drum	5						
Freshwater Drum	5						
Freshwater Drum	9						
Carpoides spp.	7.5						
Carpoides spp.	7.5						
Carpoides spp.	8						
Carpoides spp.	8						
Notropis	5						
Notropis	7.5						
Notropis	6.5						
Notropis	7						
Notropis	7.5						
Notropis	5						
Notropis	5						
Notropis	8						
Micropterus spp.	32.5						
Micropterus spp.	24						
Carp	10						

Table 3 continued

SURFACE				BOTTOM			
Sample A		Sample B		Sample A		Sample B	
Species	Length (mm)	Species	Length (mm)	Species	Length (mm)	Species	Length (mm)
July 1, 1976							
Carpoides spp.	10	Carpoides spp.	10	No Sample		No Sample	
July 19, 1976							
Gizzard Shad	13	Gizzard Shad	8	No Sample		No Sample	
Freshwater Drum	10	Gizzard Shad	12				
Freshwater Drum	8	Freshwater Drum	16				
Unidentified	5						

Unidentified = Due to damaged condition

Table 4. Species Identification

Station 3

SURFACE				BOTTOM			
Sample A		Sample B		Sample A		Sample B	
Species	Length (mm)	Species	Length (mm)	Species	Length (mm)	Species	Length (mm)
June 5, 1976							
Gizzard Shad	13	Gizzard Shad	14	0		0	
Gizzard Shad	12	Gizzard Shad	13.5				
White Bass	19	Gizzard Shad	13.5				
		Gizzard Shad	13				
		Gizzard Shad	12.5				
		White Bass	13				
		Notropis	6				
		Notropis	6.5				
June 17, 1976							
Gizzard Shad	9	Gizzard Shad	10	Gizzard Shad	9.5	Gizzard Shad	7
Gizzard Shad	10.5	Gizzard Shad	20	Freshwater Drum	5.5	Carp	5
Gizzard Shad	10	Gizzard Shad	8	Freshwater Drum	6.5		
Gizzard Shad	8	Gizzard Shad	8	Carp	7.0		
Gizzard Shad	10	Gizzard Shad	8				
Gizzard Shad	7	Gizzard Shad	7.5				
Freshwater Drum	4	Gizzard Shad	8				
Freshwater Drum	7.5	Gizzard Shad	7				
Freshwater Drum	5.5	Freshwater Drum	7				
Freshwater Drum	5	Freshwater Drum	7				
Freshwater Drum	5	Freshwater Drum	6				
Notropis	11	Freshwater Drum	7				
Notropis	11	Freshwater Drum	7				
Notropis	10	Freshwater Drum	5				
Notropis	10	Freshwater Drum	7				
Notropis	8.5	Freshwater Drum	7				
Notorpis	8.0	Freshwater Drum	7				
Notropis	7.5	Freshwater Drum	6.5				
Notropis	7.5	Freshwater Drum	6				
Notropis	6.5	Freshwater Drum	6				
Carpoides spp.	15	Freshwater Drum	7				
Carpoides spp.	15	Freshwater Drum	7				
Carpoides spp.	10	Carpoides spp.	14				
Carpoides spp.	10	Carpoides spp.	15				
Carp	7	Carpoides spp.	16				

Table 4 continued

SURFACE				BOTTOM			
Sample A		Sample B		Sample A		Sample B	
Species	Length (mm)	Species	Length (mm)	Species	Length (mm)	Species	Length (mm)
			June 17, 1976 continued				
		Carpoides spp.	17				
		Carpoides spp.	13				
		Carpoides spp.	14				
		Carpoides spp.	12				
		Carpoides spp.	13				
White Bass	30	Carpoides spp.	10.5				
White Bass	25	Carpoides spp.	13				
White Bass	17.5	Carpoides spp.	7				
White Bass	12	Carpoides spp.	11				
White Bass	12	Notropis	12				
Unidentified	13	Notropis	10				
Unidentified	7	Notropis	10				
Unidentified	6	Notropis	9				
Unidentified	9	Notropis	9				
		Notropis	7				
		Notropis	7.5				
		Notropis	6.5				
		Notropis	8.5				
		Notropis	7.5				
		Notropis	7.5				
		Notropis	7				
		Notropis	7				
		Notropis	10				
		Notropis	7.5				
		Notropis	7.5				
		Notropis	8				
		Notropis	7.5				
		Notropis	7				
		Notropis	6				
		Notropis	8				
		White Bass	22				
		White Bass	18.5				
		White Bass	12				
		Unidentified	7				

Table 4 continued

SURFACE				BOTTOM			
Sample A		Sample B		Sample A		Sample B	
Species	Length (mm)	Species	Length (mm)	Species	Length (mm)	Species	Length (mm)
			July 1, 1976				
Gizzard Shad	10	Gizzard Shad	11	0		Gizzard Shad	12.5
Gizzard Shad	14	Gizzard Shad	11			Gizzard Shad	15
Gizzard Shad	9.5	Gizzard Shad	10				
Gizzard Shad	8.5	Gizzard Shad	8				
Gizzard Shad	9.5	Gizzard Shad	9				
Gizzard Shad	8.5	Gizzard Shad	10				
Gizzard Shad	11	Gizzard Shad	9				
Gizzard Shad	8.5	Gizzard Shad	10				
Gizzard Shad	7	Gizzard Shad	8				
Gizzard Shad	8	Gizzard Shad	10				
Gizzard Shad	9	Gizzard Shad	10				
Gizzard Shad	8	Gizzard Shad	10				
Gizzard Shad	8	Gizzard Shad	9				
Gizzard Shad	17.5	Gizzard Shad	7				
Gizzard Shad	14	Gizzard Shad	12				
Freshwater Drum	7	Freshwater Drum	23				
Freshwater Drum	6.5	Unidentified	5				
Unidentified	8						
			July 19, 1976				
Gizzard Shad	10	Gizzard Shad	10	0		0	
Gizzard Shad	9	Gizzard Shad	11				
Gizzard Shad	11	Gizzard Shad	12				
			August 9, 1976				
0		0		No Sample		No Sample	

Unidentified - Due to damaged condition

Table 5. Reproduction Histories of Ichytoplankton Taxa Likely to be Found in the Des Moines River Near the Ottumwa Generating Station

Species	Spawning period	Spawning temperature (°C)	Incubation days	Spawning habitat	Number of eggs	References
Gizzard Shad	Early May through June	18-27	1.5-7	Adhesive eggs broadcast in shallow areas usually less than 3 feet in depth	22,000-544,000	Bodola, 1966; Dendy, 1946; Jester, 1962; Jester, et. al., 1972; Mayhew, 1957.
Northern Pike	Early April to early May	4.4-10.5	4-5	Adhesive eggs deposited over vegetation in marshy areas along streams or connected sloughs, in shallow water usually less than 12 inches.	7,700-97,300	Franklin and Smith, 1963; Scott and Crossman, 1973; Threinen, et. al., 1966.
Cyprinidae	Mid-April through August	14.5-25.5	1-1.5	Adhesive eggs broadcast at random over a variety of substrates and depths	1,500-2,000,000	Harlan and Speaker, 1956; Starrett, 1951.
Carp	Mid-May to Early August	17-24	3-6	Adhesive eggs broadcast at random over muck bottoms, plant beds, debris in shallow water of less than 4 feet and usually less than 1 foot.	20,000-2,000,000	Frey, 1940; Jester 1974; Sigler, 1958; Swe, et. al., 1966.
Ictiobus spp.	Late April to early June	13.9-23.9	4-8	Adhesive eggs randomly broadcast over mud bottoms, vegetation in shallow calm areas.	150,000-250,000	Johnson, 1963; Scott and Crossman, 1973; Walburg and Nelson, 1966; Wrenn and Grinstead, 1968.
Channel Catfish	End of May through July	21-29	5-10	Eggs deposited in gelatinous mass in nests built under logs, rocks and overhanging banks in protected water.	2,000-70,000	Clemens and Snead 1957, Cross, 1951; Katz, 1954; Miller, 1966; Scott and Crossman, 1973.
White Bass	Late May to Mid June	14.4-24	2-3	Adhesive eggs broadcast near surface or in midwater over gravelly or rocky bottoms.	140,000-994,000	Ruelle, 1971; Scott and Crossman, 1973.
Pomoxis spp.	Early May to Mid June	14-23	2-5	Builds nest in shallow water near brush, stumps, often on plant material.	11,000-194,000	Goodson, 1966; Siefert, 1968; 1969.
Freshwater Drum	May through August	18-24.5	1-2	Open water and at surface.	43,000-508,000	Daiber, 1953; Swedberg and Walburg, 1970.
Walleye	March to Mid-May	2.2-15.6	10-20	Adhesive eggs broadcast in shallow gravelly or sandy areas or in tributary streams.	35,000-6000,000	Johnson, 1961; Scott and Crossman, 1973.

Table 5 continued

Species	Spawning period	Spawning temperature (°C)	Incubation days	Spawning habitat	Number of eggs	References
Carpoides spp.	April - June			Eggs scattered over sand or mud bottom, shallow water		Lippson and Moran, 1974; Mansuetti and Hardy, 1967.
Micropterus spp.	May - July	15.5 - 25	3-4	Adhesive eggs deposited in nests, may or may not have preference for gravel bottom	2,500-10,000	Lippson and Moran, 1974; pflieger, 1975.

NOTE: Some species or genera were omitted due to the unlikelihood of presence as ichthyoplankton in the study area.

SOURCE; Adapted from Operational Environmental Monitoring in the Mississippi River Near Quad-Cities Station, February 1975 Thrugh January 1976 Text, Table 7.1, pp. 231-232, NALCO Environmental Sciences, Northbrook, Illinois.

Table 6

Summary of Des Moines River Flows at Ottumwa
Water Years 1970-1974 (in thousands of cfs)

	1970			1971			1972			1973			1974			1975		
Month	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.
Oct.	2.9	1.9	1.0	13.2	4.4	.7	.5	.4	.2	10.6	5.8	2.7	22.1	18.4	15.2	1.2	.6	.5
Nov.	3.9	2.1	1.2	6.1	3.4	1.3	3.6	1.7	.7	17.0	13.8	7.8	17.4	11.3	4.7	4.1	2.1	1.1
Dec.	2.0	1.2	.8	5.6	2.9	1.5	4.2	1.6	.4	10.2	5.5	2.9	16.4	10.8	5.2	4.0	1.9	.5
Jan.	3.2	1.0	.5	1.6	1.2	.6	1.7	.8	.5	18.2	12.4	5.6	19.9	8.8	4.0	3.8	1.4	.6
Feb.	3.0	1.6	.8	31.3	9.4	.9	2.9	.9	.4	27.0	16.5	7.2	14.8	9.1	4.6	2.6	1.3	.9
Mar.	13.2	6.1	1.3	26.3	18.6	9.4	6.2	4.7	2.6	27.7	16.8	6.5	21.1	12.8	7.0	24.1	7.5	.9
Apr.	13.0	7.7	5.0	18.2	9.7	4.5	7.1	3.1	1.6	31.6	24.6	15.4	17.5	12.6	6.9	20.0	16.4	12.9
May	17.0	10.0	3.4	7.9	5.5	3.4	19.5	10.8	5.8	32.0	24.8	18.1	24.2	15.2	8.0	18.4	11.8	5.6
June	8.1	4.7	2.4	12.5	6.6	2.8	13.9	8.8	4.1	23.7	19.2	17.9	26.6	18.6	15.4	19.5	16.6	13.6
July	2.1	1.4	1.0	9.8	4.4	2.2	13.2	6.0	2.3	22.9	19.6	18.3	21.6	15.6	9.0	17.5	9.3	1.5
Aug.	13.5	2.7	.5	1.6	1.0	.3	17.7	9.7	2.7	19.8	17.4	13.7	8.8	4.9	1.6	7.6	1.8	.7
Sept.	10.6	2.8	.3	1.1	.4	.05	15.7	7.7	1.3	23.4	7.0	3.5	1.5	1.0	.6	7.3	1.9	.7

Table 6 continued

Summary of Water Years
1970 - 1975

Month	Maximum (in 6 yr. period)	Mean (in 6 yr. period)	Minimum (in 6 yr. period)
October	22.1	5.3	.2
November	17.4	5.7	.7
December	16.4	4.0	.4
January	19.9	4.3	.5
February	31.3	6.5	.4
March	27.7	11.1	.9
April	31.6	12.4	3.1
May	32.0	13.0	3.4
June	26.6	12.4	2.4
July	22.9	9.4	1.0
August	19.8	6.3	.3
September	23.4	3.5	.05

APPENDIX C

TERRESTRIAL BIOLOGICAL DATA

TABLE C-1

Terrestrial mammals seen (s), captured (c) or expected (e) on the Ottumwa site

Species	Habitat	Range in Region or state	Abundance in region	Range in U.S.	Project Impact
Opossum (s) Didelphis marsupialis	Woodlands and Forest	Statewide	Common	Entire U.S.	Minimal
Short-tailed shrew (c) Blarina brevicauda	Mesic grasslands, and woods	Statewide	Common	Eastern U.S.	Minimal
Least shrew (e) Cryptotis parva	Grasslands, esp. with brush	Statewide	Rare	Eastern U.S.	Moderate, local population
Masked shrew (c) Sorex cinereus	Grasslands and fencerows	Northern 2/3 of state	Occasional	Northern U.S.	Minimal
Eastern Mole (s) Scalopus aquaticus	Grasslands	Statewide	Occasional	Eastern U.S.	Minimal
Cottontail Rabbit (s) Sylvilagus floridanus	Grasslands and brush	Statewide	Abundant	Eastern 2/3	Minimal
Woodchuck (s) Marmota monax	Grasslands	Statewide	Occasional	Eastern U.S.	Minimal
Thirteen-lined ground squirrel (s) Spermophilus tridecemlineatus	Grasslands	Statewide	Occasional	Central U.S.	Minimal
Eastern Chipmunk (s) Tamias striatus	Woods and brush	Statewide	Occasional	Eastern U.S.	Minimal
Fox squirrel (s) Sciurus niger	Woodland and forest	Statewide	Common	Eastern 2/3	Minimal

TABLE C-1 (cont.)

Species	Habitat	Range in Region or state	Abundance in region	Range in U.S.	Project Impact
Gray Squirrel (e) *Sciurus carolinensis*	Forests, esp. with mut trees	Statewide	Occasional	Eastern U.S.	Minimal
Flying squirrel (e) *Glaucomys volans*	Woods	Statewide	Rare	Eastern U.S.	Moderate, local population depression
Plains pocket gopher (s) *Geomys bursarius*	Grasslands	Statewide	Common	Central Plains	Minimal
Meadow jumping mouse (c) *Zapus hudsonius*	Mesic grasslands and open areas	Statewide	Rare	Northern and eastern	Moderate, local population depression
Western harvest mouse (e) *Reithrodontomys megalotis*	Mesic grassland	Statewide	Occasional	Western U.S., except northern Rockies	Moderate, local population depression
Deer mouse (c) *Peromyscus maniculatus*	Drier grasslands and open woods	Statewide	Common	Entire U.S. except S.E.	Minimal
White-footed mouse (c) *Peromyscus leucopus*	Woods and brush, occas. open areas	Statewide	Abundant	Eastern 2/3	Minimal
Meadow vole (c) *Microtus pennsylvanicus*	Mesic grasslands	Mostly northern 2/3 of state	Occasional	Northern	Minimal
Prairie vole (c) *Microtus ochrogaster*	Dry grasslands	Mostly southern 2/3 of state	Rare	Northern Plains	Moderate, local population depression

TABLE C-1 (cont.)

Species	Habitat	Range in Region of state	Abundance in region	Range in U.S.	Project Impact
Pine vole (e) *Pitymys pinetorum*	Forests with heavy litter layer	Eastern ½ of state	Rare	Eastern U.S.	Moderate, local population depression
Southern bog lemming (e) *Synaptomys cooperi*	Wet meadows	Statewide	Rare	Eastern U.S., north of Tenn.	Moderate, local population depression
Muskrat (s) *Ondatra zibethica*	Marshes, stream edges, swamps	Statewide	Occasional	Most of U.S.	Minimal
House mouse (c) *Mus musculus*	Fields, around human habitation	Statewide	Common	Entire U.S.	Minimal
Norway rat (s) *Rattus novegicus*	Around human habitation and farms	Statewide	Common near farms	Entire U.S.	Minimal
Raccoon (s) *Procyon lotor*	Woods with access to water	Statewide	Occasional	Most of U.S. except western mountains	Minimal
Coyote (e) *Canis latrans*	Prairies and open brush	Statewide	Occasional	U.S. west of Appalachians	Minimal
Gray fox *Urocyon cinereoargenteus*	Woods and edges	Statewide	Rare	Eastern and southwestern U.S.	Moderate, local population depression
Red fox (s) *Vulpes fulva*	Hilly areas with a mosaic of woods and open areas	Statewide	Occasional	Most of U.S. except dry steppe	Moderate, local population depression
Mink (e) *Mustela vison*	Along water	Statewide	Occasional	Entire U.S. except southwest	Minimal
Long-tailed weasel (e) *Mustela frenata*	Any habitat with access to water	Statewide	Occasional	Entire U.S. except Sonoran Prov.	Minimal

TABLE C-1 (cont.)

Species	Habitat	Range in Region or state	Abundance in region	Range in U.S.	Project Impact
Striped skunk (s) Mephitis mephitis	Open woods, prairies, brush	Statewide	Common	Entire U.S.	Minimal
Spotted skunk (e) Spilogale putorius	Open woods, prairies, brush	Statewide	Occasional	Most of U.S. except North-east	Moderate, local population depression
Badger (e) Taxidea taxus	Grasslands	Statewide	Rare	Western U.S.	Moderate, local population depression
White-tailed deer (s) Odocoileus virginianus	Woods and brushy edges	Statewide	Occasional	Most of U.S. except desert states	Moderate, local population depression

TABLE C-2

Birds of the Ottumwa Site. "Ott." indicates a highly probable presence in the area.

A - ABUNDANT
C - COMMON
U - UNCOMMON
O - OCCASIONAL
R - RARE
B - BLUE LISTED
T - THREATENED

	SPECIES		RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS															EFFECT OF PROJECT ACTION					
			PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
C	Common loon Gavia immer					X	X																	X			
R	Red-necked grebe Podiceps grisegena					X	X																	X			
O	Horned grebe Podiceps auritis					X	X																	X			
O	Eared grebe Podiceps caspicus					X	X																	X			
C	Pied-billed grebe Podilymbus podiceps	Ott.		X			X	X															X				
R	White pelican Pelecanus erythrorhychos					X	X																	X			
C	Double-crested cormorant Phalacrocorax auritus	Ott.		X		X	X																	X			
C	Great blue heron Ardea herodias	Ott. (seen)		X			X	X	X														X				
C	Green heron Butorides virescens	Ott. (seen)		X			X	X	X														X				
O	Little blue heron Florida caerul			X				X	X															X			

TABLE C-2 (cont.)

A - ABUNDANT
C - COMMON
U - UNCOMMON
O - OCCASIONAL
R - RARE
B - BLUE LISTED
T - THREATENED

	SPECIES		RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS																EFFECT OF PROJECT ACTION					
			PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER		HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
O	Common egret *Casmerodius albus*			X			X	X	X																X			
U	Black-crowned night heron *Nycticorax nycticorax*			X				X	X																X			
R	Yellow-crowned night heron *Nyctanassa violacea*			X				X	X																X			
U	Least bittern *Ixobrychus exilis*	Ott.		X				X	X															X				
R	American bittern *Botaurus lentiginosus*			X		X		X	X																X			
O	Whistling swan *Olor columbianus*					X	X																		X			
A	Canada goose *Branta canadensis*	Ott. (seen)				X	X	X			X	X												X				
R	White-fronted goose *Anser albifrons*					X	X				X	X													X			
U	Snow goose *Chen hyperborea*					X	X	X			X	X													X			
A	Mallard *Anas platyrhychos*	Ott. (seen)		X		X	X	X	X															X				

TABLE C-2 (cont.)

A - ABUNDANT
C - COMMON
U - UNCOMMON
O - OCCASIONAL
R - RARE
B - BLUE LISTED
T - THREATENED

	SPECIES		RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS															EFFECT OF PROJECT ACTION					
			PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
U	Black duck Anas rubripes	Ott.			X	X	X	X	X														X				
U	Gadwall Anas strepera	Ott.				X	X	X	X														X				
A	Pintail Anas acuta	Ott.				X	X	X	X														X				
C	Green-winged teal Anas carolinensis	Ott.				X	X	X	X														X				
A	Blue-winged teal Anas discors	Ott. (seen)		X		X	X	X	X														X				
C	American widgeon Mareca americana					X	X																	X			
C	Shoveler Spatula clypeata	Ott.				X	X	X	X														X				
C	Wood duck Aix sponsa	Ott. (seen)		X			X	X	X														X				
C	Redhead Aythya americana			X			X																	X			
C	Ring-necked duck Aythya collaris					X	X																	X			

TABLE C-2 (cont.)

A - ABUNDANT
C - COMMON
U - UNCOMMON
O - OCCASIONAL
R - RARE
B - BLUE LISTED
T - THREATENED

			RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS															EFFECT OF PROJECT ACTION					
	SPECIES		PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
U	Canvas-back Aythya valisineria					X	X																	X			
A	Lesser Scaup Aythya affinis	Ott.				X	X																X				
U	Common goldeneye Bucephala clangula					X	X																	X			
U	Bufflehead Bucephala albeola					X	X																	X			
R	Oldsquaw Clangula hyemalis					X	X																	X			
R	White-winged scoter Melanitta deglandi					X	X																	X			
U	Ruddy duck Oxyura jamaicensis	Ott.		X			X	X															X				
U	Hooded merganser Lophodytes cucullatus	Ott.		X			X	X	X														X				
C	Common merganser Mergus merganser	Ott.			X	X	X	X	X														X				
O	Red-breasted merganser Mergus serrator					X	X																	X			

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			RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS																EFFECT OF PROJECT ACTION					
	SPECIES		PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER		HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
U	Turkey vulture *Cathartes aura*	Ott. (seen)		X							X	X	X	X		X								X				
R	Goshawk *Accipiter gentilis*				X	X									X	X	X	X							X			
U	Sharp-shinned hawk *Accipiter striatus*	Ott.	X												X	X		X						X				
U	Cooper's Hawk *Accipiter cooperii*	Ott.	X												X	X		X						X				
C	Red-tailed hawk *Buteo jamaicensis*	Ott. (seen)	X								X	X	X	X	X	X								X				
R	Red-shouldered hawk *Buteo lineatus*		X							X						X									X			
C	Broad-winged hawk *Buteo platypterus*	Ott.		X		X					X	X	X	X	X	X								X				
U	Rough-legged hawk *Buteo lagopus*	Ott.			X						X	X	X	X										X				
C	Bald eagle *Haliaeetus leucocephalus*	Ott.			X	X				X														X				
C	Harrier *Circus cyaneus*	Ott. (seen)	X			X		X					X	X										X				

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			PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
O	Osprey Pandion haliaetus	Ott. (seen)				X				X													X				
R	Peregrine falcon Falco peregrinus					X									X	X								X			
O	Merlin Falco columbarius					X		X				X	X	X										X			
C	Kestrel Falco sparverius	Ott.	X	X								X	X	X									X				
C	Bobwhite quail Colinus virginianus	Ott. (seen)	X								X	X	X	X									X				
A	Ring-necked pheasant Phasianus colchicus	Ott. (seen)	X								X	X	X	X									X				
R	King rail Rallus elegans			X				X																X			
C	Virginia Rail Rallus limicola	Ott.		X				X																X			
U	Sora Porzana carolina	Ott.		X				X																X			

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			RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS																EFFECT OF PROJECT ACTION					
	SPECIES		PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	SHORES	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
R	Yellow rail *Coturnicops noveboracensis*					X		X																	X			
R	Black rail *Laterallus jamaicensis*					X		X																	X			
O	Common gallinule *Gallinula chloropus*			X				X																	X			
C	American coot *Fulica americana*	Ott. (seen)		X			X	X																X				
U	Semi-palmated plover *Charadrius semipalmatus*					X																X			X			
A	Killdeer *Charadrius vociferus*	Ott. (seen)		X						X	X	X										X		X				
C	American golden plover *Pluvialis dominica*	Ott.				X					X	X										X		X				
U	Black-bellied plover *Squatarola squatarola*					X					X	X										X			X			
R	Ruddy turnstone *Arenaria interpres*					X																X			X			
U	American woodcock *Philohela minor*	Ott.		X				X	X	X														X				

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			PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	SHORES	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
C	Common snipe Capella gallinago	Ott.			X	X		X	X															X				
U	Upland plover Bartramia longicauda	Ott.		X								X	X	X										X				
C	Spotted sandpiper Actitis macularia	Ott.		X																		X		X				
C	Solitary sandpiper Tringa solitaria	Ott.				X																X		X				
R	Willet Catoptrophorus semipalmatus					X																X			X			
C	Greater yellowlegs Totanus melanoleucus	Ott.				X																X		X				
C	Lesser yellowlegs Totanus flavipes	Ott.				X																X		X				
A	Pectoral sandpiper Erolia melanotos	Ott.				X		X														X		X				
U	White-rumped sandpiper Erolia fuscicollis	Ott.				X																X		X				
U	Baird's sandpiper Erolia bairdii	Ott.				X																X		X				

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			PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	SHORES	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
C	Least sandpiper Erolia minutilla	Ott.				X																X		X				
U	Dunlin Erolia alpina					X																X			X			
O	Long-billed dowitcher Limnodromus scolopaceus					X																X			X			
R	Stilt sandpiper Micropalama himantropus					X																X			X			
C	Semipalmated sandpiper Ereunetes pusillus	Ott.				X																X		X				
O	Hudsonian godwit Limosa haemastica					X																X			X			
R	Sanderling Crocethis alba					X																X			X			
O	Wilson's phalarope Steganopus tricolor					X	X															X			X			
C	Herring gull Larus argentatus	Ott.			X	X	X				X	X										X			X			
C	Ring-billed gull Larus delawarensis	Ott.			X	X	X				X	X										X			X			

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			PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	SHORES	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
R	Franklin's gull Larus pipixcan					X	X						X									X			X			
C	Bonaparte's gull Larus philadelphia	Ott.				X	X															X			X			
C	Forster's tern Sterna forsteri	Ott.				X	X	X					X									X			X			
U	Common tern Sterna hirundo	Ott.				X	X															X			X			
O	Least tern Sterna albifrons			X			X	X														X			X			
U	Caspian tern Hydroprogne caspia	Ott. (seen)				X	X															X			X			
C	Black tern Childonias nigra	Ott.		X		X	X	X														X			X			
A	Rock dove Columba livia	Ott. (seen)	X								X	X							X	X					X			
A	Mourning dove Zenaidura macroura	Ott. (seen)	X	X							X	X	X	X	X	X								X				
C	Yellow-billed cuckoo Coccyzus americanus	Ott.		X											X	X								X				

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C	Black-billed cuckoo Cuccyzus erythropthalmus	Ott.				X									X	X								X				
R	Barn owl Tyto alba		X								X	X	X	X											X			
C	Screech owl Otus asio	Ott.	X											X	X	X								X				
C	Great-horned owl Bubo virginianus	Ott. (seen)	X										X	X	X	X		X						X				
C	Barred owl Strix varia	Ott.	X							X						X								X				
O	Long-eared owl Asio otus		X		X											X	X	X							X			
U	Short-eared owl Asio flammeus	Ott.	X		X			X				X	X	X										X				
R	Chuck-will's-widow Caprimulgus carolinensis					X				X															X			
U	Whip-poor-will Caprimulgus vociferus	Ott.		X												X								X				

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	SPECIES		PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
A	Common nighthawk Chordeiles minor	Ott.		X								X	X	X	X				X				X				
A	Chimney swift Chaetura pelagica	Ott.		X								X	X	X					X					X			
C	Ruby-throated hummingbird Archilochus colubris	Ott.		X									X	X	X				X				X				
C	Belted kingfisher Magaceryle alcyon	Ott. (seen)		X				X	X							X							X				
A	Flicker Colaptes auratus	Ott. (seen)	X	X								X	X	X	X								X				
C	Red-bellied woodpecker Centurus carolinus	Ott. (seen)	X							X					X	X							X				
A	Red-headed woodpecker Melanerpes erythrocephalus	Ott. (seen)	X	X								X	X	X	X								X				
C	Yellow-bellied sapsucker Sphyraicus varius	Ott.				X									X	X		X					X				
C	Hairy woodpecker Dendrocopus villosus	Ott. (seen)	X							X						X	X		X				X				
A	Downy woodpecker Dendrocopus pubescens	Ott. (seen)	X							X						X	X		X				X				

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A	Eastern kingbird Tyrannus tyrannus	Ott. (seen)		X										X	X	X								X				
C	Great crested flycatcher Myiarchus crinitus	Ott.		X											X	X								X				
C	Eastern phoebe Sayornis phoebe	Ott. (seen)		X										X	X	X								X				
U	Yellow-bellied flycatcher Empidonax flaviventris	Ott. (seen)				X											X	X						X				
R	Acadian flycatcher Empidonax virescens			X					X	X						X									X			
C	Traill's flycatcher Empidonax traillii	Ott.		X					X	X														X				
C	Least flycatcher Empidonax minimus	Ott.				X								X	X									X				
C	Eastern wood pewee Contopus virens	Ott.		X											X	X								X				
O	Olive-sided flycatcher Nuttallornis borealis					X											X								X			
A	Horned lark Eremophila alpestris	Ott.	X								X	X	X	X										X				

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U	Tree swallow Iridoprocne bicolor	Ott.		X					X	X													X				
A	Bank swallow Riparia riparia	Ott. (seen)		X						X										X			X				
C	Rough-winded swallow Stelgidopteryx ruficollis	Ott.		X																X			X				
A	Barn swallow Hirundo rustica	Ott. (seen)		X							X	X		X					X				X				
U	Cliff swallow Petrochelidon pyrrhonota	Ott.		X															X	X			X				
C	Purple martin Progne subis	Ott. (seen)		X							X	X							X				X				
A	Blue-jay Cyanocitta cristata	Ott. (seen)	X	X								X		X	X	X							X				
A	Common crow Corvus brachyrhynchos	Ott. (seen)	X								X	X	X	X	X	X							X				
A	Black-capped chickadee Parus atricapillus	Ott. (seen)	X											X	X	X							X				
C	Tufted titmouse Parus bicolor	Ott. (seen)	X											X	X	X							X				

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A	White-breasted nuthatch Sitta carolinensis	Ott. (seen)	X												X	X		X					X				
U	Red-breasted nuthatch Sitta canadensis	Ott.			X												X	X					X				
U	Brown creeper Certhia familiaris	Ott.	X		X										X	X							X				
A	House wren Troglodytes aëdon	Ott. (seen)		X											X				X				X				
O	Winter wren Troglodytes troglodytes	Ott.				X				X					X	X							X				
U	Bewick's wren Thryomanes bewickii	Ott.		X												X			X				X				
R	Carolina wren Thryothorus ludovicianus		X												X									X			
C	Long-billed marsh wren Telmatodytes palutris	Ott.		X				X															X				
U	Short-billed marsh wren Cistothorus platensis	Ott.		X				X					X										X				
U	Mockingbird Mimus polyglottos	Ott. (seen)		X										X	X				X				X				

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A	Catbird Dumetella carolinensis	Ott. (seen)		X											X	X							X				
A	Brown thrasher Toxostoma rufum	Ott. (seen)		X										X	X	X							X				
A	Robin Turdus migratorius	Ott. (seen)	X	X								X	X	X	X	X							X				
C	Wood thrush Hylocichla mustelina	Ott. (seen)		X											X	X							X				
C	Hermit thrush Hylocichla guttata	Ott.				X												X					X				
C	Swainson's thrush Hylocichla ustulata	Ott.				X											X						X				
C	Gray-cheeked thrush Hylocichla minima	Ott.				X											X						X				
O	Veery Hylocichla fuscencens	Ott.				X				X						X							X				
C	Eastern bluebird Sialia sialis	Ott.	X	X										X	X								X				
U	Blue-gray gnatcatcher Polioptila caerulea	Ott.		X						X						X							X				

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	SPECIES		RESIDENT STATUS: PERMANENT	RESIDENT STATUS: SUMMER	RESIDENT STATUS: WINTER	RESIDENT STATUS: TRANSIENT	HABITAT PREFERENCE AND RESTRICTIONS: AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	SHORES	EFFECT OF PROJECT ACTION: HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
C	Golden-crowned kinglet Regulus satrapa	Ott. (seen)				X										X	X	X						X				
C	Ruby-crowned kinglet Regulus calendula	Ott. (seen)				X										X	X	X						X				
O	Water pipet Anthus spinoletta					X					X	X	X	X								X			X			
R	Sprague's pipit Anthus spragueii					X						X	X												X			
R	Bohemian waxwing Bombycilla garrula				X									X	X										X			
U	Cedar waxwing Bombycilla cedrorum	Ott. (seen)		X										X	X									X				
U	Loggerhead shrike Lanius ludovicianus	Ott.		X									X	X										X				
A	Starling Sturnus vulgaris	Ott. (seen)	X								X	X		X	X				X						X			
R	White-eyed vireo Vireo griseus			X											X	X									X			
C	Bell's vireo Vireo bellii	Ott.		X						X														X				

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B - BLUE LISTED
T - THREATENED

	SPECIES		RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS															EFFECT OF PROJECT ACTION					
			PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
C	Yellow-throated vireo Vireo flavifrons	Ott.		X											X	X							X				
C	Solitary vireo Vireo solitarius	Ott.				X												X					X				
A	Red-eye vireo Vireo olivaceus	Ott.		X											X	X							X				
R	Philadelphia vireo Vireo philadelphicus					X									X	X								X			
A	Warbling vireo Vireo gilvus	Ott.		X											X	X		X					X				
C	Black and white warbler Mniotilta varia	Ott.				X									X	X							X				
C	Prothonotary warbler Protonotaria citrea	Ott.		X					X														X				
R	Worm-eating warbler Helmitheros vermivorus					X										X								X			
R	Golden-winged warbler Vermivora chrysoptera					X									X	X								X			
R	Blue-winged warbler Vermivora pinus			X					X						X									X			

TABLE C-2 (cont.)

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	SPECIES		RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS															EFFECT OF PROJECT ACTION					
			PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
A	Tennessee warbler *Vermivora peregrina*	Ott.				X			X							X	X						X				
C	Orange-crowned warbler *Vermivora celata*	Ott.				X								X	X								X				
C	Nashville warbler *Vermivora ruficapilla*	Ott. (seen)				X									X								X				
R	Parula warbler *Parula americana*					X				X						X								X			
A	Yellow warbler *Dendroica petechia*	Ott.		X						X					X								X				
C	Magnolia warbler *Dendroica magnolia*	Ott.				X									X	X	X						X				
R	Cape May warbler *Dendroica tigrina*					X									X	X	X							X			
R	Black-throated blue warbler *Dendroica caerulescens*					X										X		X						X			
A	Myrtle warbler *Dendroica coronata*	Ott. (seen)				X									X	X	X	X					X				
U	Black-throated green warbler *Dendroica virens*	Ott.				X			X								X						X				

TABLE C-2 (cont.)

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			RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS															EFFECT OF PROJECT ACTION					
	SPECIES		PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
R	Cerulean warbler Dendroica cerulea			X						X						X								X			
U	Blackburnia warbler Dendroica fusca	Ott.				X									X	X	X						X				
C	Chestnut-sided warbler Dendroica pennsylvanica	Ott.				X								X	X	X							X				
O	Bay-breasted warbler Dendroica castanea					X											X							X			
C	Blackpoll Dendroica striata	Ott.				X									X	X	X						X				
C	Palm warbler Dendroica palmarum	Ott.				X			X						X	X	X						X				
C	Ovenbird Seiurus aurocapillus	Ott.		X												X							X				
C	Northern waterthrush Seiurus novaboracensis	Ott.				X			X	X													X				
U	Louisiana waterthrush Seiurus motacilla	Ott.		X					X	X													X				
U	Kentucky warbler Oporornis formosus	Ott.		X						X					X	X							X				

TABLE C-2 (cont.)

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			RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS																EFFECT OF PROJECT ACTION					
	SPECIES		PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER		HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
R	Connecticut warbler Oporornis agilis					X			X								X								X			
U	Mourning warbler Oporornis philadelphis					X			X	X					X										X			
A	Yellowthroat Geothlypis trichas	Ott. (seen)		X				X	X	X				X	X									X				
U	Yellow-breasted chat Icteria virens	Ott.		X											X									X				
R	Hooded warbler Wilsonia citrina					X			X	X						X									X			
C	Wilson's warbler Wilsonia pusilla	Ott.				X			X	X						X								X				
U	Canada warbler Wilsonia canadensis	Ott.				X				X														X				
A	American redstart Setophaga ruticilla	Ott.		X											X	X								X				
A	House sparrow Passer domesticus	Ott. (seen)	X								X	X		X	X				X						X			
C	Bobolink Dolichonyx oryzivorus	Ott.		X								X	X	X										X				

TABLE C-2 (cont.)

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	SPECIES		RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS															EFFECT OF PROJECT ACTION					
			PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
A	Eastern meadowlark Sturnella magna	Ott. (seen)		X							X	X	X	X									X				
C	Western meadowlark Sturnella neglecta	Ott.		X							X	X	X	X									X				
C	Yellow-headed blackbird Xanthocephalus xanthocephalus			X				X																X			
A	Red-winged blackbird Agelaius phoeniceus	Ott. (seen)	X	X				X			X	X		X	X								X				
O	Orchard oriole Icterus spurius	Ott.		X										X	X								X				
A	Baltimore oriole Icterus galbula	Ott. (seen)		X											X	X							X				
C	Rusty blackbird Euphagus carolinus	Ott.				X			X	X						X							X				
U	Brewer's blackbird Euphagus cyanocephalus	Ott.				X							X	X									X				
A	Common grackle Quiscalus quiscala	Ott. (seen)	X	X							X	X	X	X	X									X			
C	Brown-headed cowbird Molothrus ater	Ott. (seen)		X							X	X	X	X	X								X				

TABLE C-2 (cont.)

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	SPECIES		RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS															EFFECT OF PROJECT ACTION					
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U	Scarlet tanager Piranga olivacea	Ott.		X											X	X							X				
U	Summer tanager Piranga rubra	Ott.		X											X	X							X				
A	Cardinal Richmondena cardinalis	Ott. (seen)	X											X	X	X							X				
C	Rose-breasted grosbeak Pheucticus ludovicianus	Ott. (seen)		X						X					X	X							X				
C	Indigo bunting Passerina cyanea	Ott. (seen)		X										X	X								X				
A	Dickcissel Spiza americana	Ott. (seen)		X								X	X	X									X				
O	Evening grosbeak Hesperiphona vespertina				X	X									X	X	X	X						X			
C	Purple finch Carpodacus purpureus	Ott.			X										X		X	X					X				
R	Pine grosbeak Pinicola enucleator				X												X							X			
U	Common redpoll Acanthis flammea	Ott.			x								X	X	X								X				

TABLE C-2 (cont.)

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	SPECIES		RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS															EFFECT OF PROJECT ACTION					
			PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
U	Pine siskin Spinus pinus	Ott.			X												X						X				
C	American goldfinch Spinus tristis	Ott. (seen)		X	X							X	X	X									X				
U	Red crossbill Loxia curvirostra				X												X							X			
R	White-winged crossbill Loxia leucoptera				X												X							X			
C	Rufus-sided towhee Pipilo erythrophthalmus	Ott. (seen)		X											X	X							X				
C	Savannah sparrow Passerculus sandwishensis	Ott.		X		X							X	X									X				
C	Grasshopper sparrow Ammodramus savannarum	Ott. (seen)		X								X	X	X									X				
U	LeConte's sparrow Passerherbulus caudacutus	Ott.				X		X					X										X				
R	Henslow's sparrow Passerherbulus henslowii			X									X	X										X			
R	Sharp-tailed sparrow Ammospiza caudacuta					X		X																X			

TABLE C-2 (cont.)

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	SPECIES		PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
C	Vesper sparrow *Pooecetes gramineus*	Ott.		X								X	X	X									X				
C	Lark sparrow *Chondestes grammacus*	Ott.		X								X	X	X									X				
A	Slate-colored junco *Junco hyemalis*	Ott. (seen)			X										X		X						X				
A	Tree sparrow *Spizella arborea*	Ott.			X										X	X							X				
C	Chipping sparrow *Spizella passerina*	Ott. (seen)		X											X				X				X				
U	Clay-colored sparrow *Spizella pallida*					X							X		X									X			
C	Field sparrow *Spizella pusilla*	Ott. (seen)		X								X		X	X								X				
O	Harris's sparrow *Zonotrichia querula*				X	X								X	X		X							X			
U	White-crowned sparrow *Zonotrichia leucophrys*	Ott.			X	X								X	X		X						X				
A	White-throated sparrow *Zonotrichia albicollis*	Ott. (seen)				X								X	X		X						X				

TABLE C-2 (cont.)

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	SPECIES		RESIDENT STATUS				HABITAT PREFERENCE AND RESTRICTIONS															EFFECT OF PROJECT ACTION					
			PERMANENT	SUMMER	WINTER	TRANSIENT	AQUATIC	MARSH	SWAMP	RIPARIAN	CROPLAND	PASTURE - HAYLAND	PRAIRIE	OLD FIELDS	FOREST EDGE	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	URBAN	CLIFFS AND BANKS	OTHER	HIGHLY DETRIMENTAL	MODERATELY DETRIMENTAL	PRESENT STATUS OR NO APPARENT IMPACT	SLIGHTLY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	HIGHLY ADVANTAGEOUS
C	Fox sparrow **Passerella iliaca**	Ott. (seen)				X								X	X		X						X				
C	Lincoln's sparrow **Melospiza lincolnii**	Ott.				X			X	X					X								X				
C	Swamp sparrow **Melospiza georgiana**	Ott.		X		X		X	X	X					X								X				
A	Song sparrow **Melospiza melodia**	Ott. (seen)		X	X								X	X	X								X				
U	Lapland longspur **Calcarius lapponicus**				X	X					X	X	X											X			

TABLE C-3

Amphibians of South-east Iowa that may occur on the Ottumwa Site

Species	Habitat	Range in state	Estimated Abundance in state	Range in U.S.	Estimated Project Impact
Mudpuppy Necturus maculosus	Permanent water	Eastern 2/3	Common	Central to Appalachians	Minimal
Central newt Notophthalmus viridescens	Ponds and small streams	Eastern 1/4	Common	Eastern ¼ of U.S.	Minimal
Small-mouthed salamander Ambystoma texanum	Ponds and river-bottom forest	Southern	Rare	South-central	Local population depression
Eastern tiger salamander Ambystoma tigrinum	Ponds	Statewide	Common	East of Rockies	Minimal
American toad Bufo americanus	Anywhere if enough water for breeding	Statewide	Abundant	Eastern ½ of U.S.	Minimal
Spring peeper Hyla crucifer	Second-growth woods near water	Eastern 1/3	Rare	Eastern 1/3 of U.S.	Local population depression
Treefrog Hyla versicolor	Trees in/near water	Statewide	Common	Eastern ½ of U.S.	Minimal
Western chorus frog Pseudacris triseriata	Agricultural fields and prairies	Statewide	Common	East and north	Minimal
Blanchard's cricket frog Acris crepitans	River valleys and lowlands	Statewide	Common	Central and northern	Minimal

TABLE C-3 (cont.)

Species	Habitat	Range in state	Estimated Abundance in state	Range in U.S.	Estimated Project Impact
Bullfrog *Rana catesbeiana*	Any permanent water	Southern 1/2	Common	Eastern ½ of U.S. and west coast	Minimal
Greenfrog *Rana clamitans*	Shallow water, standing or running	Eastern 1/2	Common	Eastern ½ of U.S.	Minimal
Leopard frog *Rana pipiens*	Meadows, open	Statewide	Occasional	Northern ½ of U.S.	Minimal

Sources: Conant, R. 1975. A field guide to reptiles and amphibians of eastern and central North America. 2nd ed. Boston, Houghton Mifflin.

Menzel, B. W. 1975. Course manual for zoology 306, herpetology. Iowa State Univ.

TABLE C-4

Reptiles of Southeast Iowa that may occur on the Ottumwa Site

Species	Habitat	Range in state	Estimated Abundance in state	Range in U.S.	Estimated Project Impact
Turtles:					
Common snapping turtle *Chelydra serpentina*	Ponds and lakes	Statewide	Common	East of Rockies	Minimal
Map turtle *Graptemys geographica*	Large rivers and lakes	Eastern 1/4	Occasional	Mid-eastern	Minimal
Western painted turtle *Chrysemys picta*	Shallow, muddy ponds and marshes	Statewide	Common	North-central and north-western	Minimal
Blanding's turtle *Emydoidea blandingi*	Small bodies of water	North and southeast	Rare	North-central	Local population depression
Ornate box turtle *Terrapene ornata*	Grasslands, esp. sandy	Statewide	Rare	South-central	Local population depression
Smooth softshell turtle *Trionyx muticus*	Streams	Major rivers	Common	Central	Minimal
Spiny softshell turtle *Trionyx spiniferus*	Rivers and larger lakes	Statewide	Common	Central, and east to Appalachians	Minimal
Lizards:					
Western slender glass lizard *Ophisaurus attenuatus*	Dry grasslands and open woods	South-east	Rare	South-central and south-east	Local population depression

TABLE C-4 (cont.)

Species	Habitat	Range in state	Estimated Abundance in state	Range in U.S.	Estimated Project Impact
Snakes:					
Northern water snake Natrix sipedon	Any body of water, esp. quiet water	Statewide	Common	Central and east	Minimal
Graham's water snake Natrix grahami	Protected water edges	Central and south-east	Occasional	South-central	Minimal
Red-side garter snake Thamnophis sirtalis	Wide range of grasslands and woods	Statewide	Abundant	All but south-west	Minimal
Plains garter snake Thamnophis radix	Near water in grasslands	Statewide	Common	North-central	Minimal
Ribbon snake Thamnophis proximus	Semi-aquatic, water edges	South-east	Common	South-central	Minimal
Dekay's snake Storeria dekayi	Moist areas	Statewide, except north-west	Common	Eastern ½ of U.S.	Minimal
Eastern hognose snake Heterodon platyrhinos	Sandy woods and open areas	Statewide, except north-west	Common	Eastern ½ of U.S.	Minimal
Prairie ringneck snake Diadophis punctatus	Rocky open woods	Mostly statewide	Common	South-central	Minimal
Smooth green snake Opheodrys vernalis	Moist grasslands	Statewide	Common	North-east and north-central	Minimal
Eastern yellow-bellied racer Coluber constrictor	Fields, brush, open woods	Statewide	Common	Plains (this subspecies)	Minimal

TABLE C-4 (cont.)

Species	Habitat	Range in state	Estimated Abundance in state	Range in U.S.	Estimated Project Impact
Bullsnake *Pituophis melanoleucus*	Grasslands	Mostly statewide	Common	Plains	Minimal
Fox snake *Elaphe vulpina*	Open moist grasslands and woods	Statewide	Common	North-central	Minimal
Black rat snake *Elaphe obsoleta*	Wide range of open to wooded	South-east	Common	Central and east	Minimal
Red milk snake *Lampropeltis triangulum*	Open agricultural land and woodlands	Mostly statewide	Common	Central and east	Minimal
Prairie kingsnake *Lampropeltis calligaster*	Grasslands	Southern	Common	South-east	Minimal
Speckled kingsnake *Lampropeltis getulus*	River and stream valleys, grasslands	Southern	Rare	Southern	Local population depression
Eastern massasauga *Sistrurus catenatus*	Wet grasslands and marshes, wet woods	Southern	Rare	East-central to Texas	Local population depression
Timber rattlesnake *Crotalus horridus*	Second-growth woods and gallery forest	South-east	Occasional	South-east and south-central	Minimal

Sources: Conant, R. 1975. A field guide to the reptiles and amphibians of eastern and central North America. 2nd ed. Boston, Houghton Mifflin.

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APPENDIX D

AIR QUALITY AND METEOROLOGICAL DATA

APPENDIX D

AIR QUALITY AND METEOROLOGICAL DATA

Methodology

Pollutant Monitoring. A monitoring program was conducted at the Ottumwa Generating Station site. Particulate matter, sulfur dioxide (SO_2), and nitrogen dioxide (NO_2) were measured. These pollutants are currently limited by federal and state regulations.

Following EPA statistical guidelines, measurements of pollutants were conducted in such a manner as to be representative of at least 75 per cent of all possible hours during a given year. Since June 2, 1975, that representation has been achieved by sampling every sixth day for 24 consecutive hours.

The scientists at Langston Laboratories, Inc. who conducted the monitoring program, used procedures described in the Federal Register, Standard Reference Methods of the Air Pollution Control Office (APCO) and methods recommended by the Intersociety Committee.

Samplers were calibrated in the laboratory prior to installation and then routinely in the field at a frequency which was dependent upon use and level of pollutants. About every 1000 hours of operation, the samplers were rebuilt to insure their operation during sampling periods.

General Metal Works High Volume Samplers were used to monitor total suspended particulate matter and Research Appliance Company (RAC) Gas Bubbler Trains were used to monitor SO_2 and NO_2 concentrations.

High volume samplers, which are installed at the site at the beginning of each sampling period, obtain an integrated quantity of total suspended particulate matter. Air is drawn into a covered housing and through a filter by means of a high flow rate motor blower. The filter allows suspended particles having diameters of less than 100 mm to pass to the filter surface. The mass concentration of suspended particulates in the ambient air ($\mu g/m^3$) is computed by measuring the mass of collected particulates and the volume of air sampled.

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The RAC gas bubbler train samples a stream of air and absorbs SO_2 and NO_2. The bubbler system is contained in a constant temperature oven and in series with calibrated orifices and a constant flow sampling pump.

A field scientist manually initiated and terminated sampling. This procedure assured that each sampling period was performed on time without error. In the field, a preweighed glass fiber filter paper was installed on the Hi-Vol sampler, the RAC bubblers prepared, the SO_2 and NO_2 trains set up, and sampling initiated. Concurrently, meteorological data were collected. After 24 hours, sampling was terminated, the filter paper from the Hi-Vol stored, and the RAC train prepared for transport to the laboratory. After the RAC train arrived at the laboratory, the solutions in the train were analyzed immediately for SO_2 and NO_2.

Nitrogen dioxide was collected by bubbling air through a sodium hydroxide-sodium arsenite solution in fritted glass bubblers to form a stable solution of sodium nitrite. The nitrite ion produced during sampling was determined colorimetrically by reacting the exposed absorbing reagent with H_2O_2, phosphoric acid, sulfanilamide, and N-1-naphthylethyldiamine dihydrochloride.

Sulfur dioxide was absorbed from air in a solution of 0.04 M potassium tetrachloromercurate. The resulting dichlorosulfitomercurate complex was reacted with pararosanaline and formaldehyde to form intensely colored (red-purple) pararosanaline methyl sulfonic acid. The absorbency of the solution was measured spectrophotometrically.

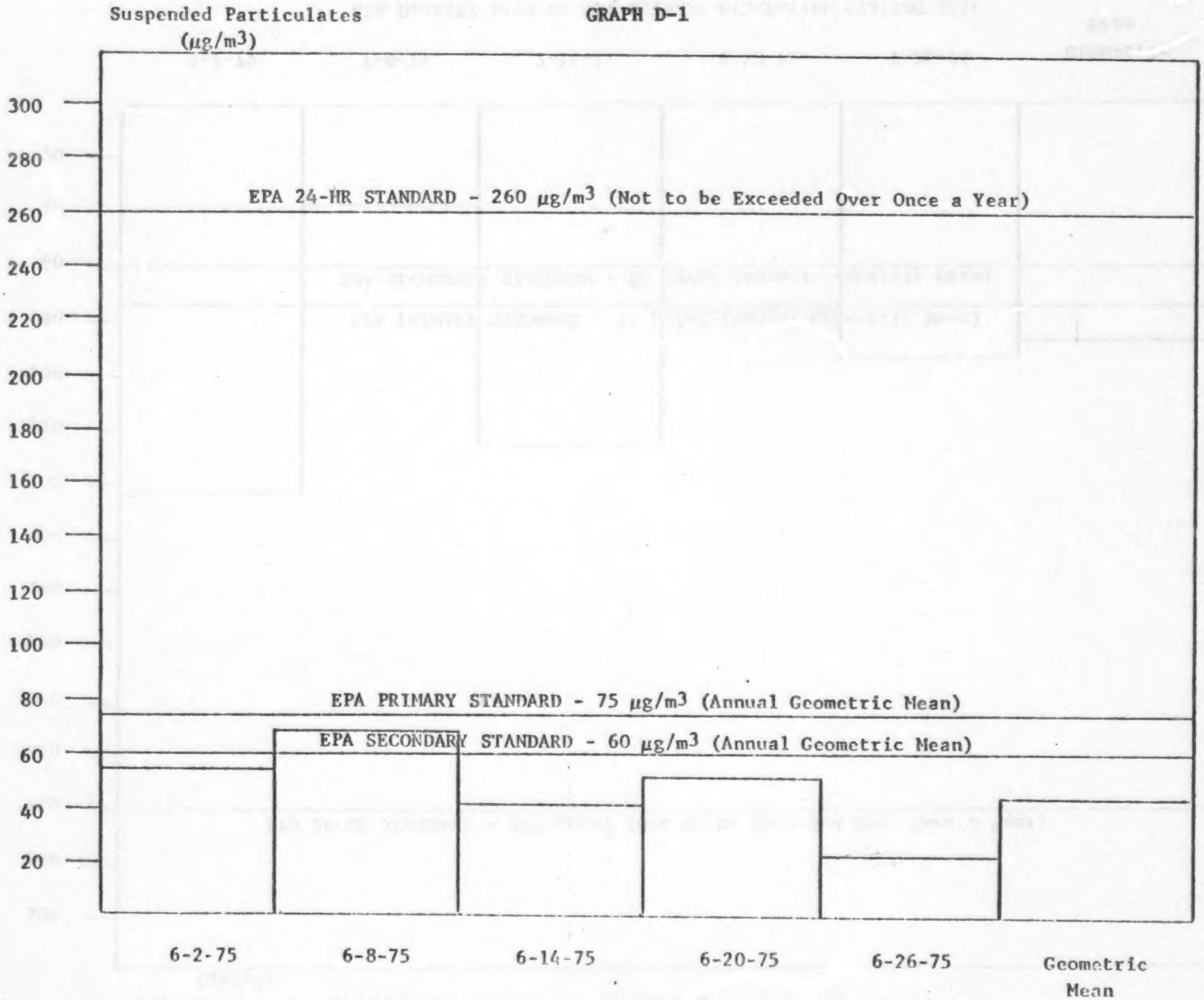
Since RAC's sampling train can handle as many as five separate bubblers at one time, the collection of SO_2 and NO_2 samples and the determination of the concentrations of these two parameters was run in duplicate. This duplicate effort was performed as a safeguard against any possible sampling error or equipment malfunction.

Meteorological Monitoring. Meteorological parameters that were determined were as follows: wind direction; wind velocity; temperature; rainfall; barometric pressure; relative humidity; and cloud cover. These climatic conditions were monitored to aid the scientists at Langston Laboratories in reporting the total suspended particulate, NO_2, and SO_2 concentrations under standard conditions (25 C and 760 mm of Hg), to facilitate the interpretation of the variations in concentration for the individual air pollutants, and to enable comparisons of the data now being generated with future ambient air quality data for the area.

The meteorological equipment that was used on this program was as follows: a Fisher Scientific continuous recording barometer, a Fisher Scientific continuous recording thermometer, a Fisher Scientific volumetric rain gage, and a Texas Electronics continuous recording wind direction and velocity system. Necessary equipment calibration was performed on a monthly basis.

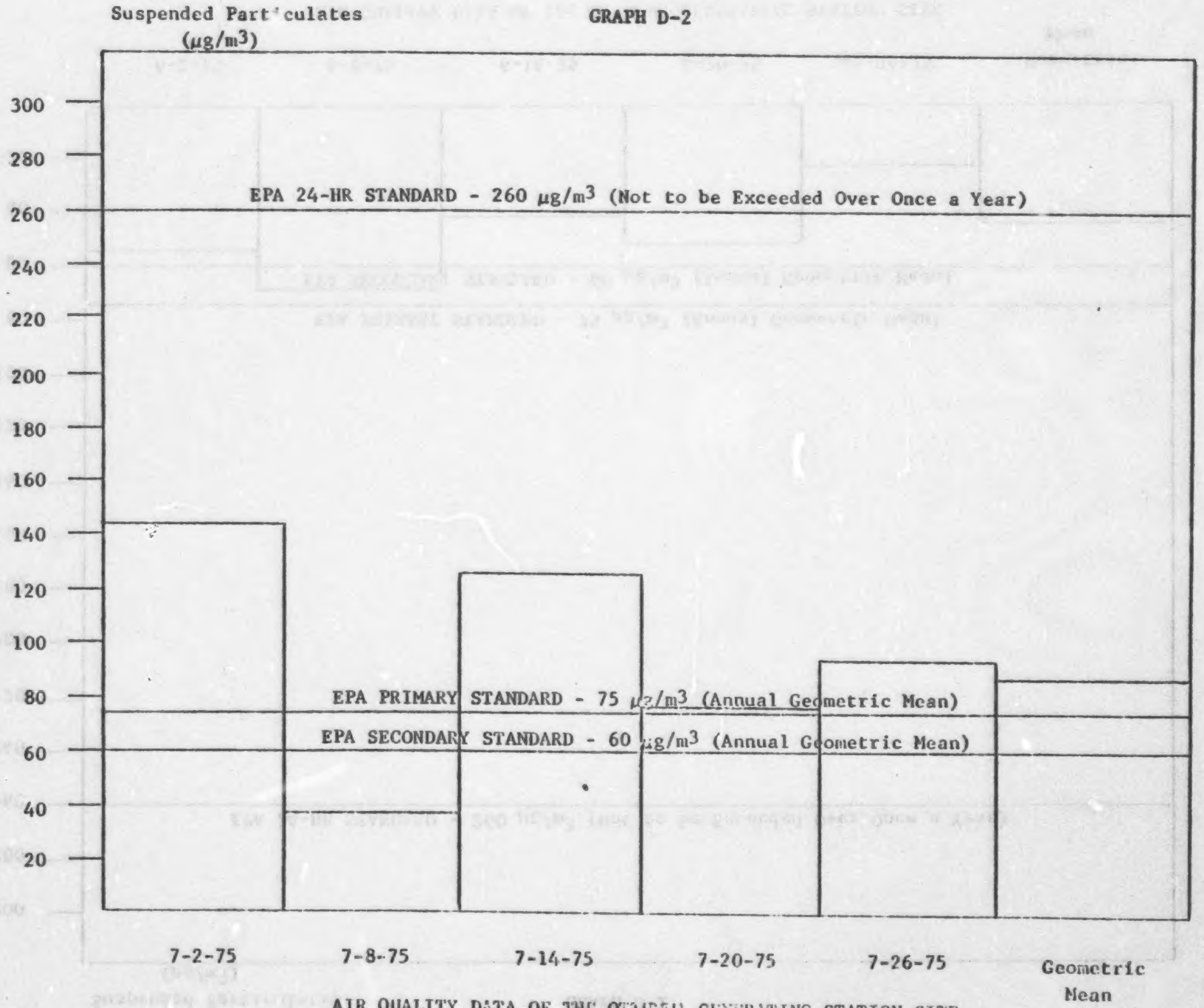
Results. Detailed ambient air qulaity data obtained during the monitoring program are illustrated in graph numbers D-1 through D-12. Data also are listed in Table D-1 and a summary of data is given in Table D-2.

GRAPH D-1



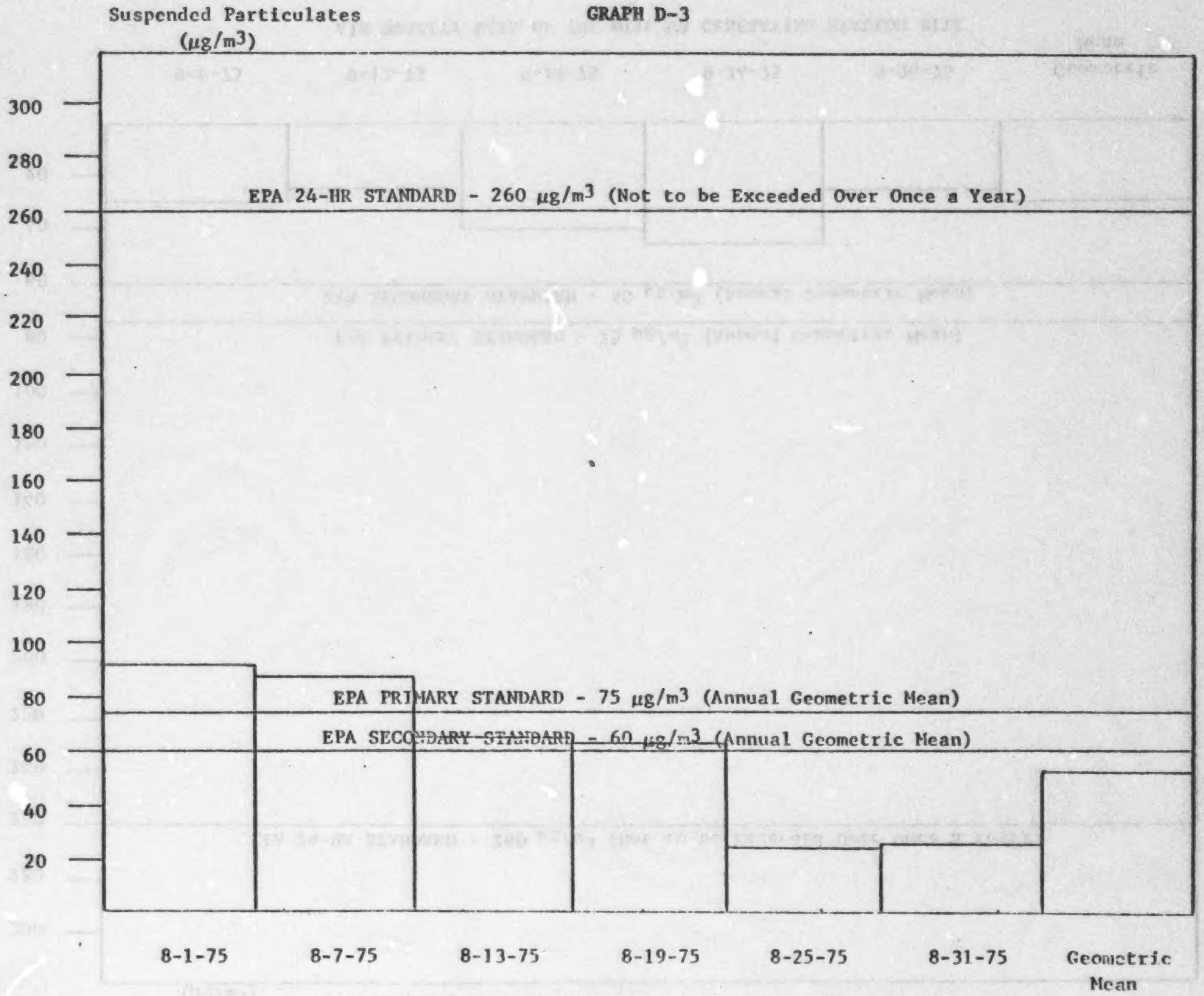
AIR QUALITY DATA OF THE OTTUMWA GENERATING STATION SITE

GRAPH D-2



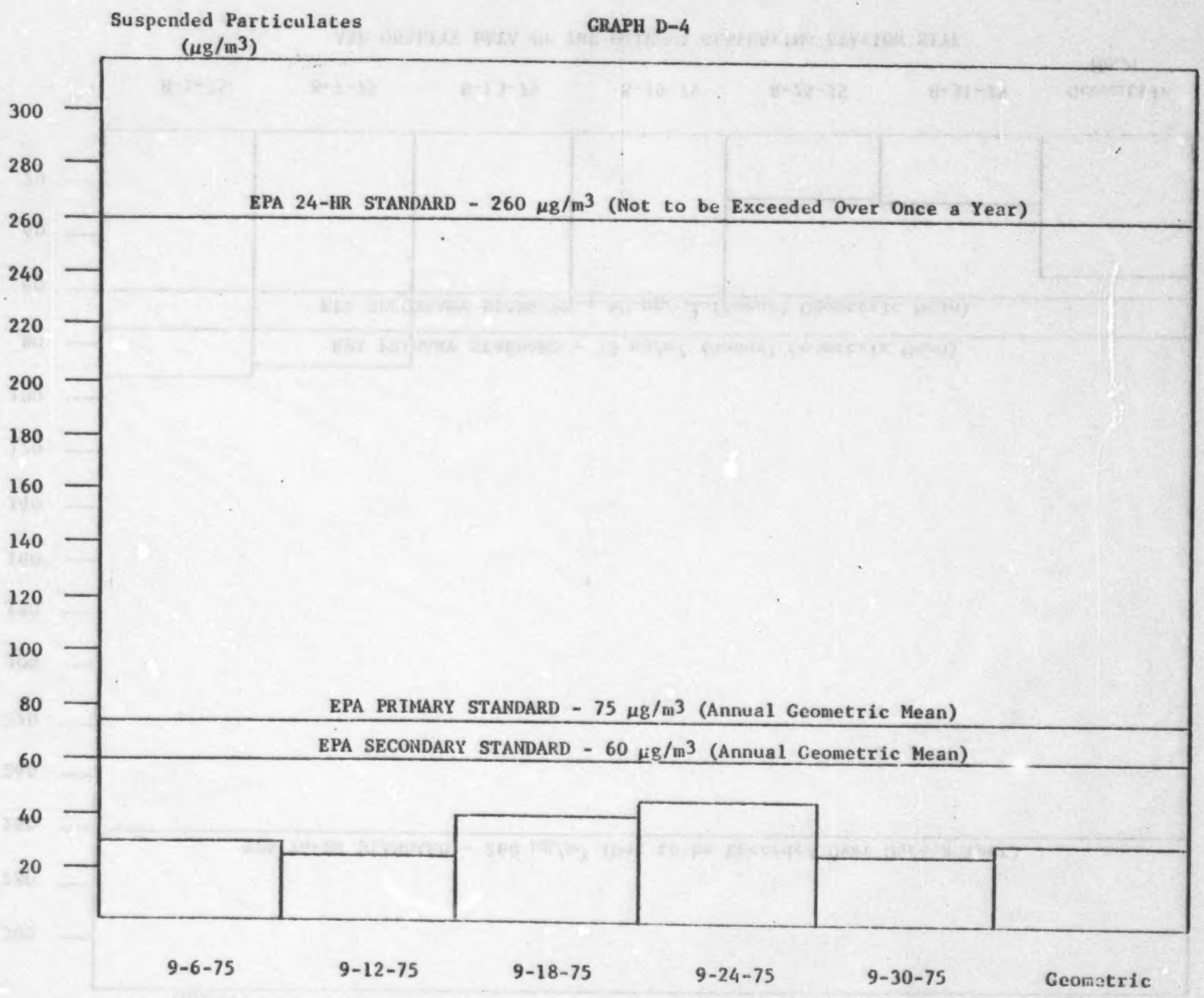
AIR QUALITY DATA OF THE OTTUMWA GENERATING STATION SITE

GRAPH D-3



AIR QUALITY DATA OF THE OTTUMWA GENERATING STATION SITE

GRAPH D-4



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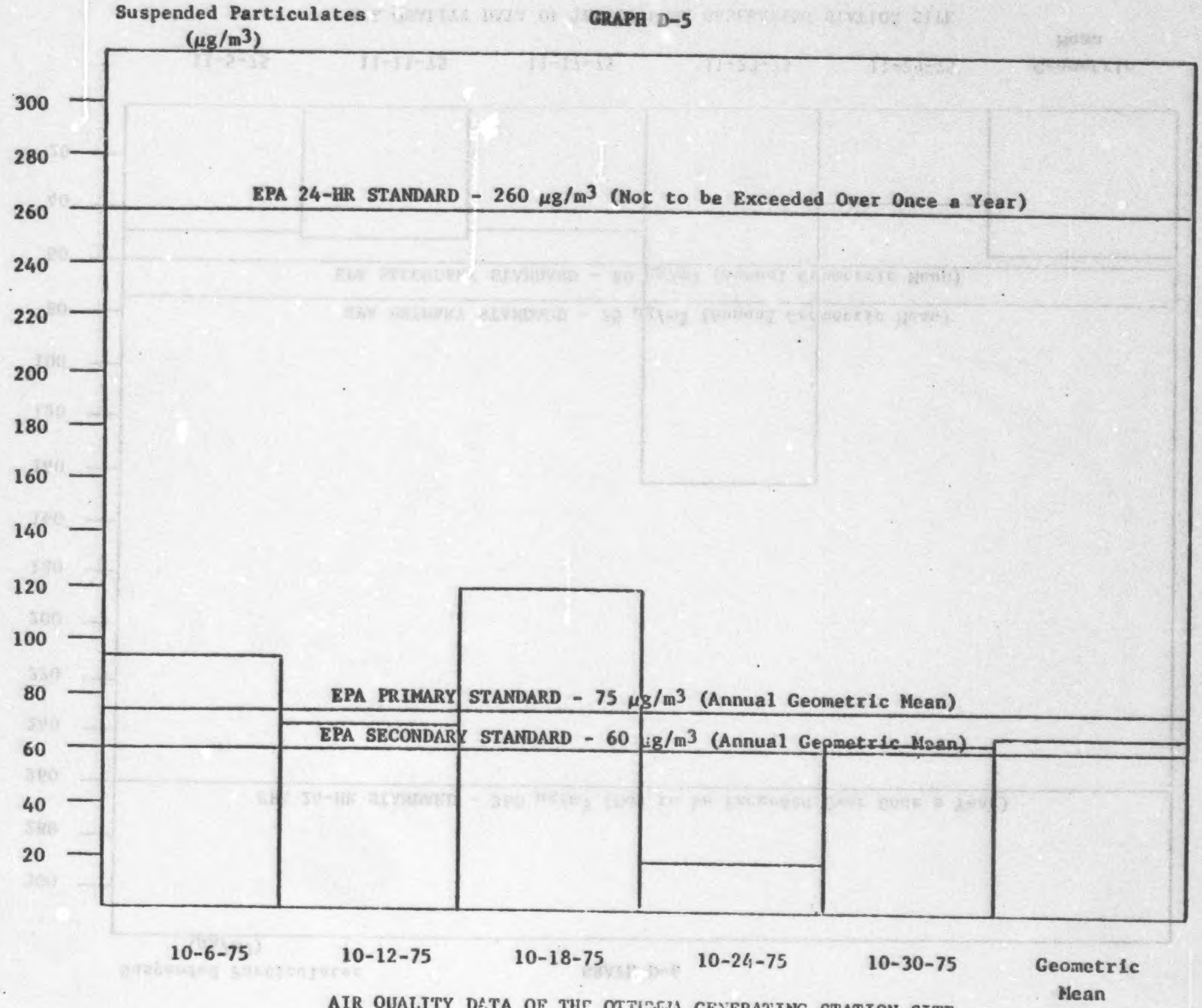
GRAPH D-5



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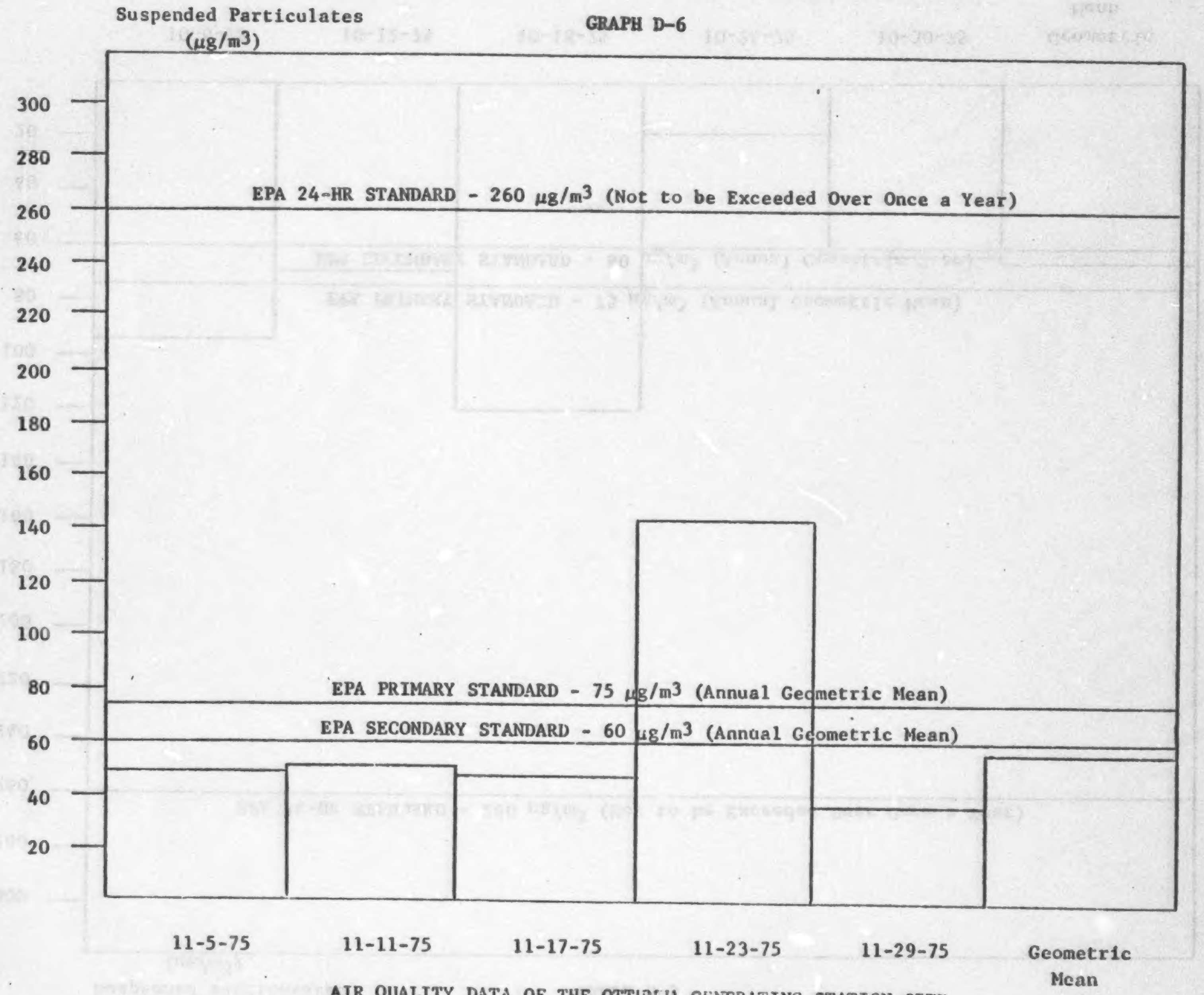
GRAPH D-6



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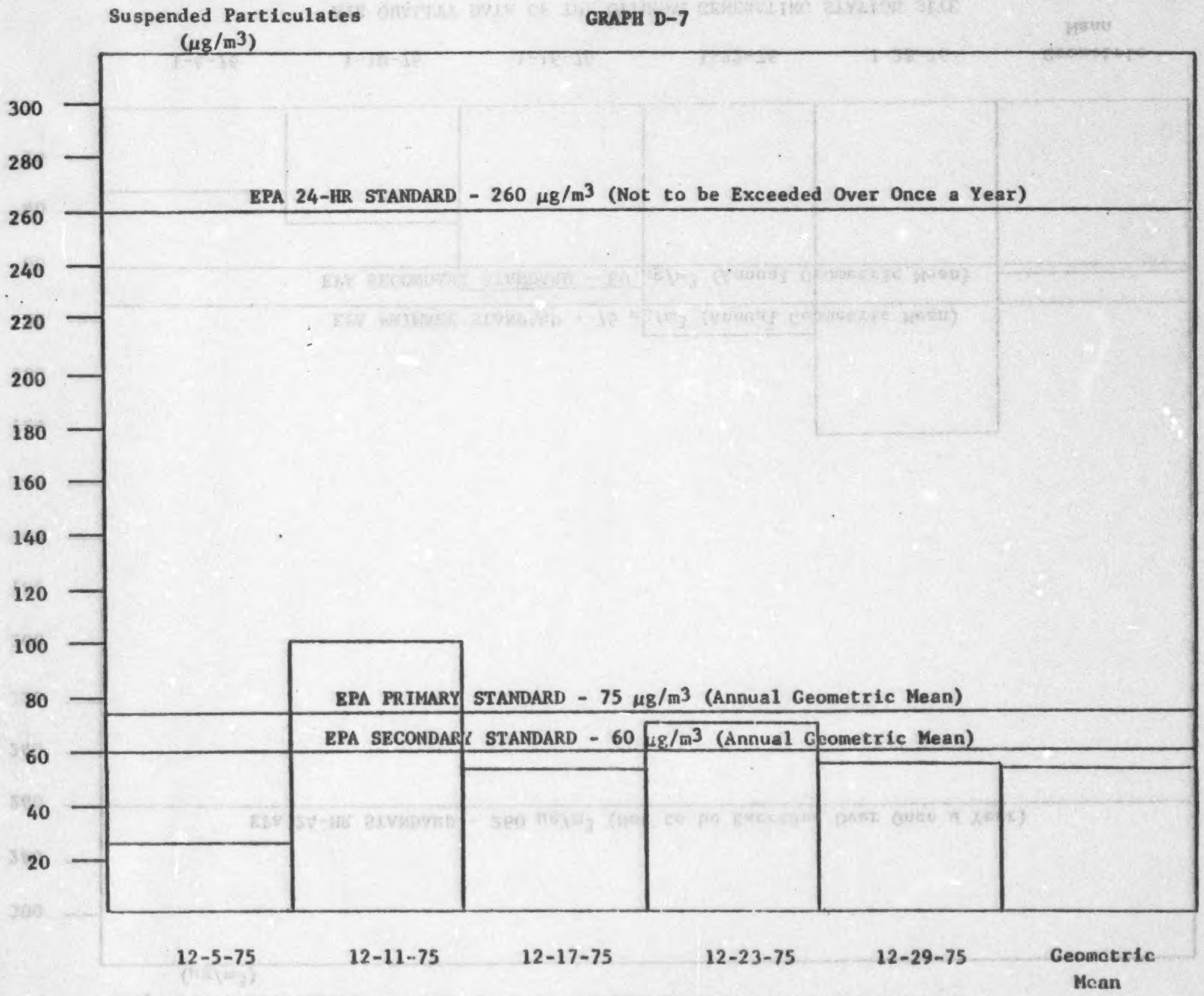
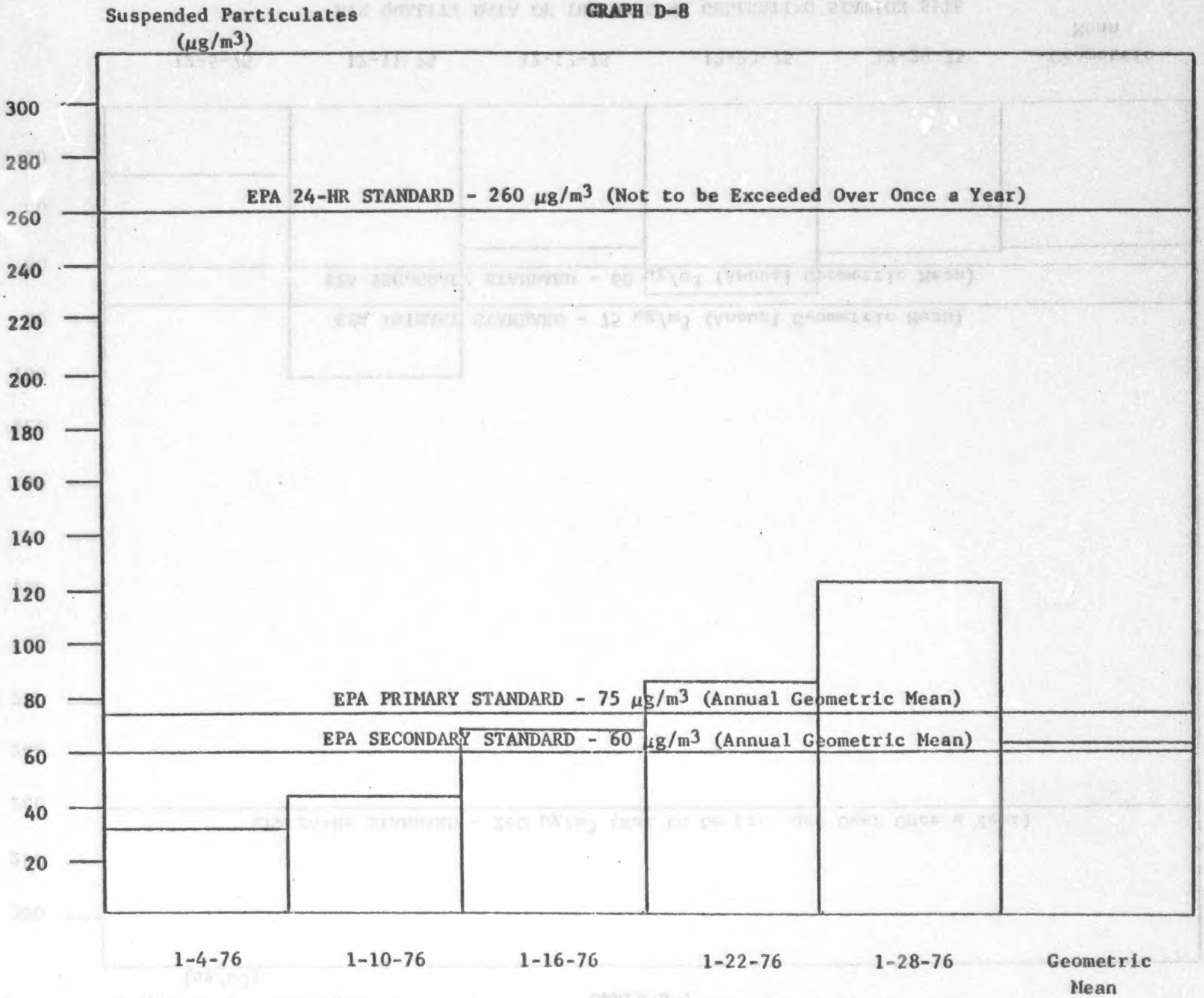


AIR QUALITY DATA OF THE OTTUMWA GENERATING STATION SITE

GRAPH D-8



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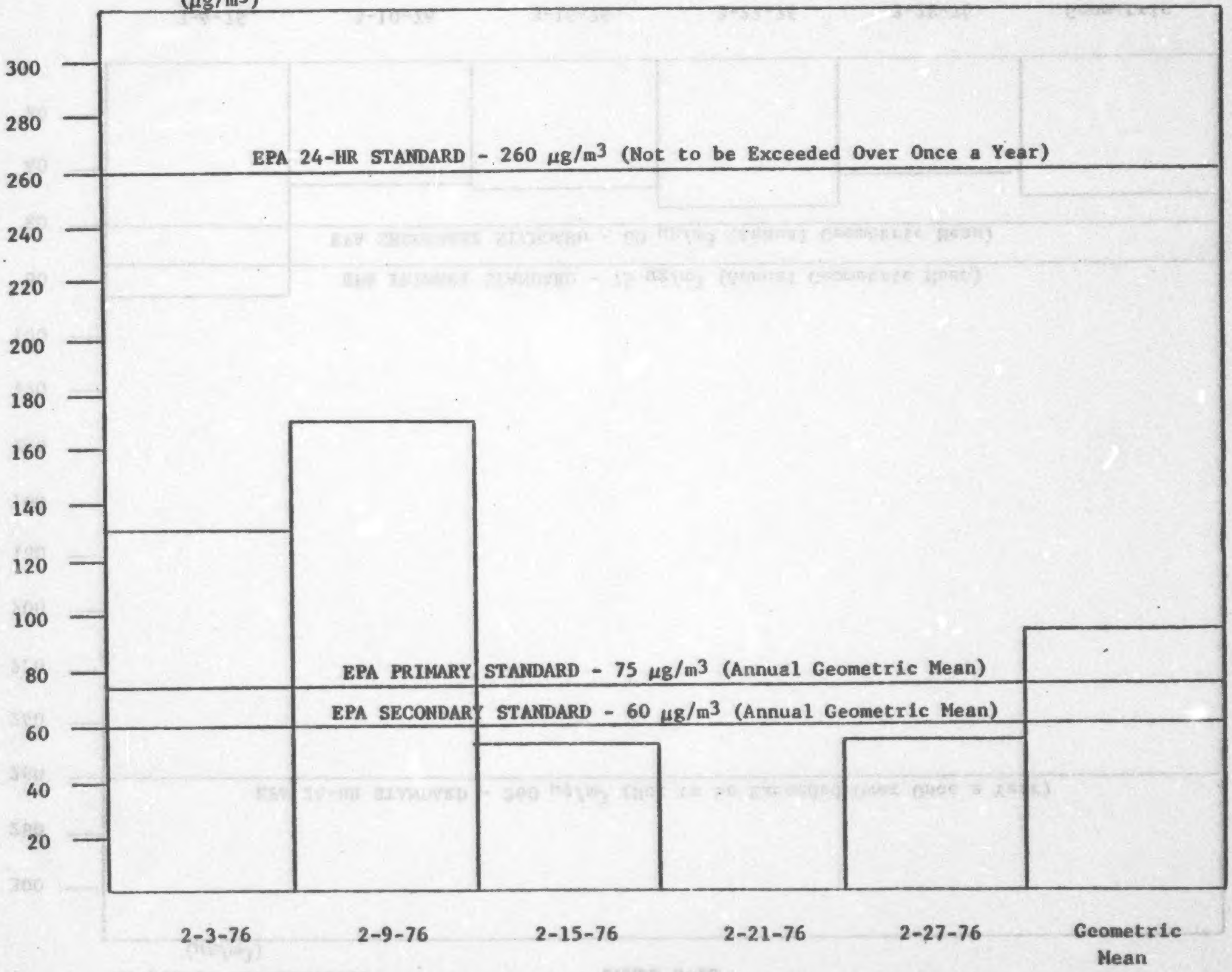
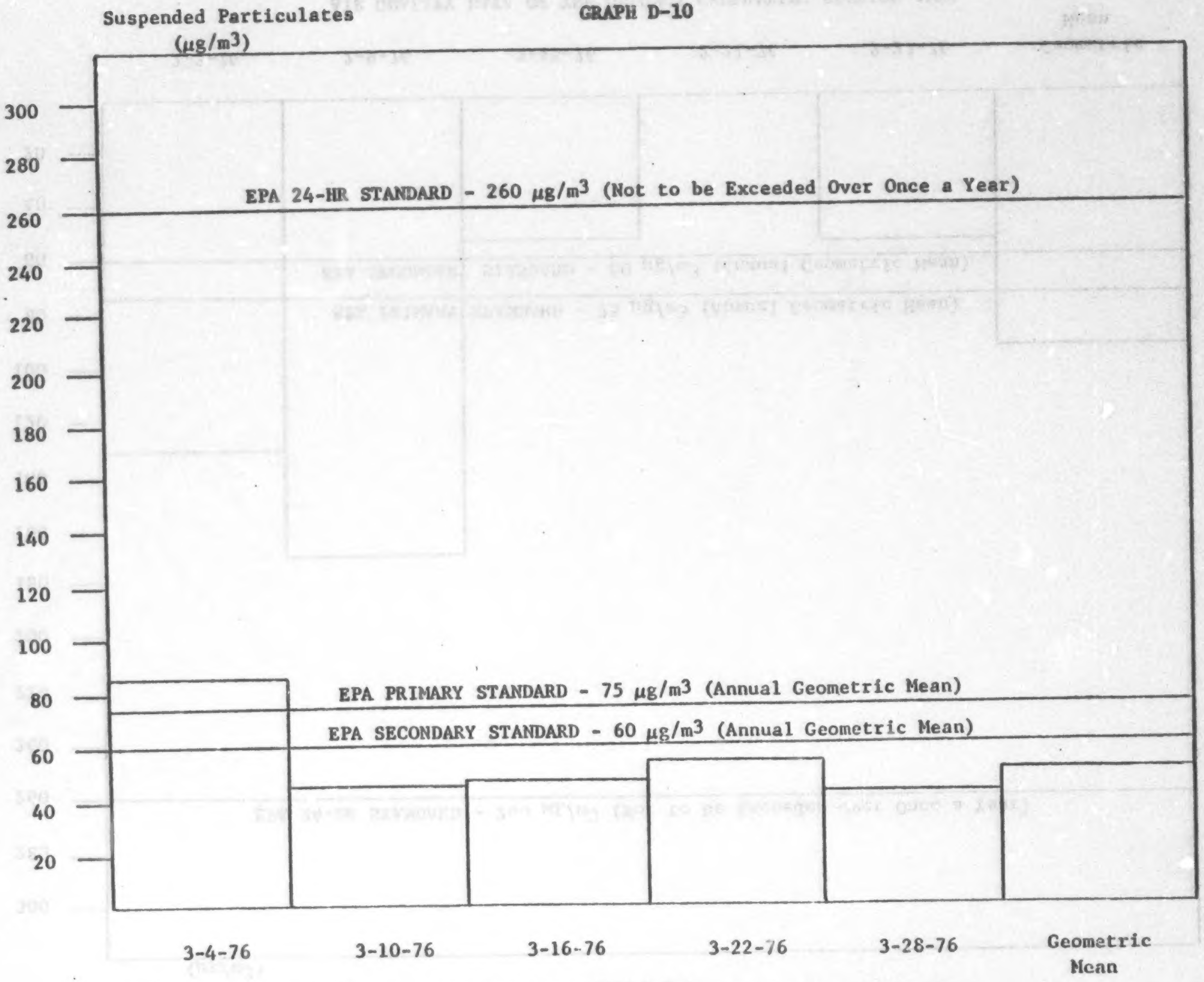
GRAPH D-9



AIR QUALITY DATA OF THE OTTUMWA GENERATING STATION SITE

GRAPH D-10



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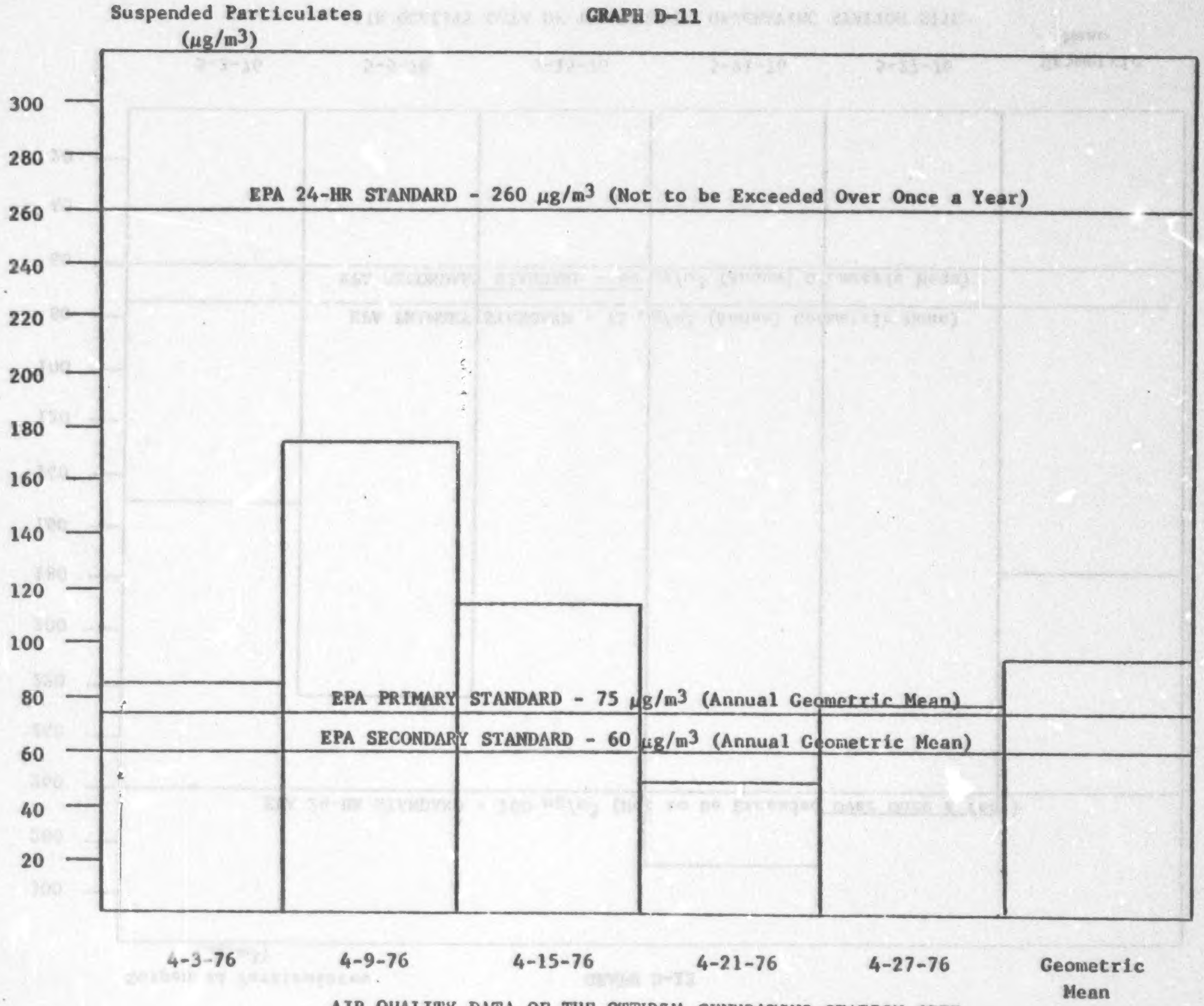
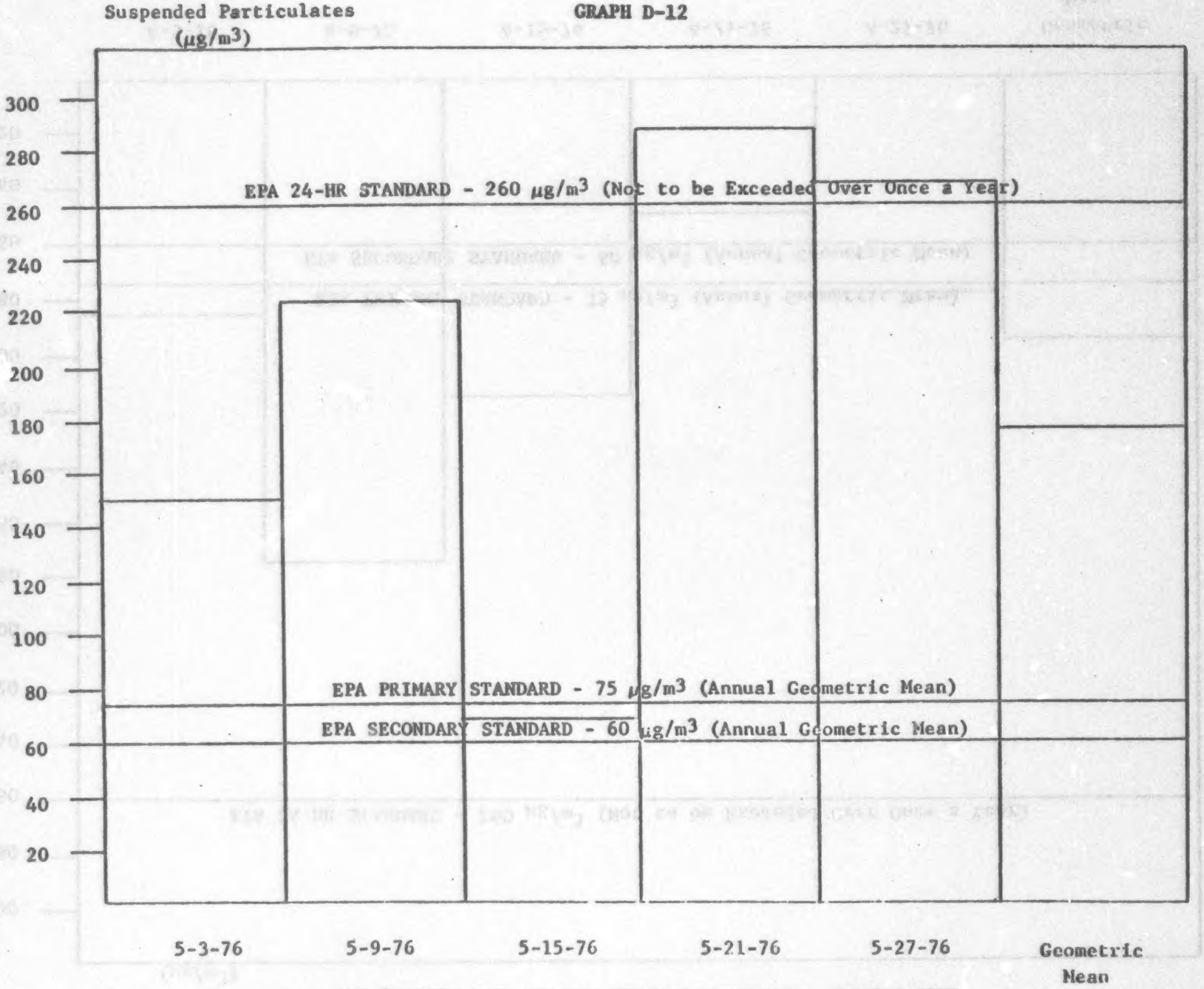
GRAPH D-11



AIR QUALITY DATA OF THE OTTUMWA GENERATING STATION SITE

GRAPH D-12



AIR QUALITY DATA OF THE OTTUMWA GENERATING STATION SITE

TABLE D-1

AIR QUALITY DATA OF THE OTTUMWA GENERATING STATION SITE

Date	NO_2 ($\mu g/m^3$)		SO_2 ($\mu g/m^3$)		Suspended Particulates ($\mu g/m^3$)	
6-2-75	25.2		3.5		54.4	
6-8-75	10.1		BDL		67.9	
6-14-75	20.1		5.4		41.4	
6-20-75	14.8		BDL		52.3	
6-26-75	67.5		3.6		24.5	
Mean	27.5	(Arith)	3.3	(Arith)	45.5	(Geometric)
7-2-75	15.5		BDL		142.7	
7-8-75	10.5		BDL		39.1	
7-14-75	10.5		BDL		124.5	
7-20-75	20.9		BDL		78.9	
7-26-75	36.5		BDL		93.4	
Mean	18.8	(Arith)	2	(Arith)	87.5	(Geometric)
8-1-75	BDL		BDL		91.6	
8-7-75	BDL		BDL		85.8	
8-13-75	BDL		BDL		65.8	
8-19-75	BDL		BDL		63.2	
8-25-75	BDL		BDL		25.1	
8-31-75	BDL		BDL		25.6	
Mean	6	(Arith)	2	(Arith)	52.5	(Geometric)
9-6-75	BDL		BDL		29.7	
9-12-75	10.9		BDL		25.5	
9-18-75	BDL		BDL		39.1	
9-24-75	BDL		BDL		43.5	
9-30-75	BDL		BDL		26.1	
Mean	7.0	(Arith)	2	(Arith)	32.0	(Geometric)
10-6-75	BDL		BDL		95.8	
10-12-75	8.4		BDL		69.0	
10-18-75	BDL		BDL		120.2	
10-24-75	BDL		BDL		20.0	
10-30-75	BDL		BDL		61.8	
Mean	6.5	(Arith)	2	(Arith)	62.9	(Geometric)

TABLE D-1 (Continued)

Date	NO_2 ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	Suspended Particulates ($\mu g/m^3$)
11-5-75	BDL	BDL	48.9
11-11-75	BDL	BDL	51.7
11-17-75	BDL	BDL	47.2
11-23-75	BDL	BDL	142.2
11-29-75	BDL	BDL	39.1
Mean	6 (Arith)	2 (Arith)	58.1 (Geometric)
12-5-75	BDL	BDL	26.2
12-11-75	BDL	22.3	100.8
12-17-75	BDL	10.5	55.3
12-23-75	BDL	BDL	69.6
12-29-75	BDL	22.1	57.0
Mean	6 (Arith)	11.8 (Arith)	56.6 (Geometric)
1-4-76	BDL	10.7	30.7
1-10-76	BDL	11.0	45.4
1-16-76	BDL	BDL	67.5
1-22-76	6.6	11.1	85.5
1-28-76	9.9	11.5	121.1
Mean	6.9 (Arith)	9.3 (Arith)	62.8 (Geometric)
2-3-76	BDL	11.1	129.4
2-9-76	BDL	10.0	171.8
2-15-76	BDL	8.7	55.7
2-21-76	---	---	---
2-27-76	BDL	11.6	57.5
Mean	6 (Arith)	10.3 (Arith)	91.9 (Geometric)
3-4-76	BDL	6.6	86.9
3-10-76	BDL	5.6	43.8
3-16-76	BDL	10.3	46.9
3-22-76	7.1	17.7	55.3
3-28-76	7.2	14.3	41.6
Mean	6.5 (Arith)	10.9 (Arith)	52.8 (Geometric)
4-3-76	BDL	17.4	84.5
4-9-76	9.1	BDL	174.0
4-15-76	BDL	BDL	115.7
4-21-76	BDL	BDL	50.7
4-27-76	15.9	BDL	77.8
Mean	8.6 (Arith)	5.1 (Arith)	92.3 (Geometric)

TABLE D-1 (Continued)

Date	NO_2 ($\mu g/m^3$)		SO_2 ($\mu g/m^3$)		Suspended Particulates ($\mu g/m^3$)	
5-3-76	10.9		BDL		149.0	
5-9-76	18.3		BDL		222.8	
5-15-76	13.2		BDL		68.7	
5-21-76	32.8		BDL		286.1	
5-27-76	25.9		BDL		267.0	
Mean	20.2	(Arith)	2	(Arith)	177.1	(Geometric)

BDL - Below Detection Limits

NOTE: The detectable limit will fluctuate because of changes in barometric pressure and temperature. The detectable limit for NO_2 is 6 $\mu g/m^3$ at standard temperature and pressure. The detectable limit for SO_2 is 2 $\mu g/m^3$ at standard temperature and pressure.

TABLE D-2

SUMMARY OF POLLUTANT RESULTS

Parameter	Minimum ($\mu g/m^3$)	Maximum ($\mu g/m^3$)	Mean ($\mu g/m^3$)	Samplings Exceeding 24 Hour Primary Standard	Samplings Exceeding 24 Hour Secondary Standard
NO_2	6 *	67.5	10.5 (arithmetic)	**	**
SO_2	2 *	22.3	5.1 (arithmetic)	0	**
Suspended Particulate Matter	20.0	286.1	65.4 (geometric)	2	5

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* Detection Limit

** Not Applicable

(NOTE: See Table D-3 for Summary of National Primary and Secondary Standards)

TABLE D-3

NATIONAL PRIMARY AND SECONDARY AMBIENT AIR QUALITY STANDARDS

	Annual Arithmetic Mean
NO_2	
Primary	100 $\mu g/m^3$
Secondary	100 $\mu g/m^3$

	24 Hour Maximum *	Annual Arithmetic Mean
SO_2		
Primary	365 $\mu g/m^3$	80 $\mu g/m^3$

	24 Hour Maximum *	Annual Geometric Mean
Suspended Particulate Matter		
Primary	260 $\mu g/m^3$	75 $\mu g/m^3$
Secondary	150 $\mu g/m^3$	60 $\mu g/m^3$

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* To be exceeded no more than once per year.

APPENDIX E

DISPERSION CALCULATIONS AND WIND DATA

GROUND LEVEL CALCULATIONS

The one-hour ground level concentrations directly downwind from an elevated source are computed using the Gaussian distribution of the plume as the following.

$$C = \frac{Q}{\pi \sigma_y \sigma_z \bar{u}} \exp \left[\frac{-h^2}{2\sigma_z{}^2}\right]$$

where:

C = downwind concentration

Q = pollutant release rate

σ_y σ_z = crosswind and vertical plume standard deviations

$\bar{u}$ = mean wind speed at the height of the stack

h = effective stack height

The σ's (one-hour average) are calculated from the downwind distance, d, as follows.

Stability Condition	σ_y meters	σ_z meters
Very Unstable	$0.40\ d^{0.91}$	$0.40\ d^{0.91}$
Unstable	$0.36\ d^{0.86}$	$0.33\ d^{0.86}$
Slightly Unstable	$0.34\ d^{0.82}$	$0.275\ d^{0.82}$
Neutral	$0.32\ d^{0.78}$	$0.22\ d^{0.78}$
Slightly Stable	$0.315\ d^{0.745}$	$0.14\ d^{0.745}$
Stable	$0.31\ d^{0.71}$	$0.06\ d^{0.71}$

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The wind speed u, is that occurring at the height of 33 feet; this is the height of the wind instrument in Burlington. For the actual computation, wind speed at the top of the stack $\bar{u}$ is computed as:

$$\bar{u} = u \left(\frac{H}{33}\right)^{0.5} \text{, stable conditions}$$

$$\bar{u} = u \left(\frac{H}{33}\right)^{0.25} \text{, unstable and neutral conditions}$$

Where H is the actual stack height in feet.

Plume rise is computed from:

$$\Delta h = 2 \left(\frac{F}{\bar{u}G}\right)^{0.33} \text{, stable condition}$$

$$\Delta h = 150 \left(\frac{F}{\bar{u}^3}\right) \text{, very unstable, unstable, and slightly unstable conditions}$$

Weighted averages are used to compute plume rise under neutral and slightly stable conditions.

$$F = \text{buoyancy flux} = g\, V_E \left[\frac{D_E}{2}\right]^2 \frac{\left[T_E - T_a\right]}{T_E}$$

$$G = \text{stability parameter} = \frac{g}{T_a} \frac{\Delta\theta}{\Delta z}$$

$\frac{\Delta\theta}{\Delta z}$ = 0.0180 C per meter

T_E, T_a = stack gas and ambient temperatures

V_E = stack gas exit velocity

D_E = chimney liner inside diameter

The effective stack height, h, is the sum of the actual stack height, H, and the plume rise, Δh.

The 3-hour concentration is computed from the one-hour concentration by the following equation.

$$\frac{C_t}{C} = \left(\frac{1}{t}\right)^r$$

in which

t = time in hours

r = varies with the dispersion conditions, as follows.

Dispersion conditions	r
Very unstable	0.65
Unstable	0.52
Slightly Unstable	0.52
Neutral	0.32
Slightly Stable	0.00
Stable	0.00

The 24-hour average is calculated from the formula.

$$\text{24-hr Average} = 1/24 \sum_i \left[T_i \; C_i \; \frac{8\sqrt{2}}{\sqrt{\pi}} \; \frac{\sigma_{yi}}{d}\right]$$

where:

T_i is the average duration in hours that a given stability condition is expected to occur.

C_i is the maximum SO_2 concentration (with respect to wind speed) that could occur during the i-th stability condition.

$\frac{8\sqrt{2}}{\sqrt{\pi}} \frac{\sigma_{yi}}{d}$ is a factor that relates the probability that the plume center line will be overhead to the probability that the plume will be somewhere in a 22-1/2 degree sector.

σ_{y_i} is the Gaussian plume width under the i-th stability

condition.

The durations, T_i, are typical for a 24-hour day with 12 hours of nighttime (annual average). For a seasonal study, these would be slightly adjusted for the actual season period of nighttime.

A base assumption in this formula is that the wind blows continuously into the 22-1/2 degree sector under investigation during the 24-hour period.

The annual average is calculated using the formula:

$$\text{Annual Average} - (1/8760)\sum_{i}\sum_{j}\left[t_{ij}\ C_{ij}\ \frac{8\sqrt{2}}{\sqrt{\pi}}\ \frac{\sigma_{yi}}{d}\right]$$

Where the tensor C_{ij} is the downwind concentration for a given wind speed, and a given stability condition.

The tensor t_{ij} is the average duration in hours that a given stability condition is expected to occur for a given wind speed times the frequency this wind speed will be in the given 22-1/2 degree sector. The assumption is made that whenever the wind is within a specific angular sector, it is distributed uniformly.

The wind speed frequency for each sector was obtained from the 1967-1971 Seasonal and Annual Wind Distribution by Pasquill Stability Classes (STAR Program) for Burlington, Iowa.

APPENDIX F

ECONOMETRIC MODEL DESCRIPTION

PRIMARY AREA ECONOMETRIC MODEL

I. Introduction

In order to measure the socioeconomic impact of OGS in the Primary Area, it was necessary to develop a tool to facilitate the estimation of future levels of economic activity. The tool employed in this analysis was a simplified econometric model of the Primary Area which captures historical economic interrelationships that have existed among key economic variables during the 25-year study period, 1950 to 1974. A list of the economic variables involved in the model is shown in Table F-1. The data base used to develop this model was derived from referenced sources by pooling historical cross-section and time-series sample data for the three counties in the Primary Area. These historical relationships are combined into a 23-equation simulation model of the Primary Area economy. These equations are shown in Table F-2. An explanation of the quantitative relationships that were estimated by multiple linear regression is contained in a subsequent section.

Once the economic relationships (equations) have been specified, certain exogenous or predetermined variables (POP, BI, FY, T, TR, and SI) are input into the computerized model to begin the order of solution and derive the expected values for each variable.

II. 1981 Price Deflator

Some of the variables included in this model are monetary variables and, due to the effects of inflation, must be deflated (or inflated) to a common base before they can be aggregated or compared. This is accomplished through the use of a 1981 price deflator derived from the historical GNP deflator as found in Business Conditions Digest. The historical GNP deflator, 1950 to 1974, is given on a 1958 base (1958 = 100). This series is projected from 1975 to 1981 by time series regression of the historical data. The estimating equation for the deflator is:

$$\text{DEFL} = 280085.7 - 21175.78 + 122.1415(T^2) + 3.518348(T^3) + .41771268(T^4)$$

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The projected 1981 deflator based on 1958 (208.55) is then used as a new base (1981 = 100) and a fraction representing each previous year 1950-1980, is derived. These factors can then be used to convert monetary variables expressed in current dollars to constant 1981 dollars.

III. Equations of the Model

A. Population Sector. A relationship to determine expected population was specified and estimated in the form shown in Table F-2. This stochastic equation specifies that, historically, population density (PDM) in the Primary Area was explained by lagged population density (PDM in each previous year), personal income (PY), and time (T). The change in Primary Area population density has historically been inversely related to the explanatory variables PY and T. This relationship serves as a test of the personal income projections and other projections used to derive personal income during the economic study period 1975-2010. Binary or "dummy" variables (D1, D2, and D3) are used to eliminate intercounty differences. The positive coefficient for logged population density (PDM) shows the accelerator effect on population due to a change in the previous year's density, in the absence of the personal income and time effect.

B. Labor Force and Employment Sector. Projected total labor force (TLF) levels were derived from the historical relationship shown in Section II of Table F-2. Total labor force and employment (EM) are divided by population (POP) so that the effects of county size are eliminated.

Projected employment in the Primary Area without OGS is derived from the historical relationship exhibited in Table F-2. This stochastic equation shows that employment can be determined from business conditions (BI), the total labor force, and time (T). There is almost a one-to-one relationship between changes in TLF and changes in EM. The Business Index has generally increased during the historical period while employment has generally decreased. In the absence of other effects, employment in the Primary Area is expected to correlate positively to time. The negative relation between BI and EM means that business activity in the Primary Area has been partially insulated from cyclical swings in the U.S. economy and can be expected to remain so for some time.

The equations, used to determine the unemployment rate (UR) and real wage rate (WR) are the identities found in Section I of Table F-2.

C. Income Sector. Personal Income (PY) projections are estimated from the identity shown in Section III of Table F-2. Transfer payments (TR) and personal contributions to social insurance (SI) are determined exogeneously. Wages and salaries (WS), and profit and proprietor income (PRY) however, are determined by the model.

Wages and salaries constitute a major portion of personal income and are projected from the historical relationship between wages and salaries, employment, and the business index; as shown in Section III of Table F-2. Wages and salaries are shown to be positively related to both employment (EM) and the business index (BI).

The stochastic equation for profit and proprietor income (PRY) shown in Section III of Table F-2 describes historical changes in the level of this variable. This relationship suggests that PRY is positively related to the business index (BI) and retail sales (RS).

Disposable income (DY) is estimated using the identity shown in the Income sector of Table F-2, which states that disposable income is personal income less taxes.

d. Agricultural Sector. Number of farms (NF) in the Primary Area was projected to the year 2010, based on its historical relationship with average value of farmland and buildings (AVLB), farm income (FY) and lagged number of farms (NF-1) as shown in Section IV of Table F-2. This equation suggests that NF is inversely related to average value of farmland and buildings (negative coefficient for AVLB in the Primary Area ignoring the effects of other variables).

Total land in farms (LF) was projected from its historical relationship with population (POP) and Time (T) using the estimating equation shown in Table F-2. This LF equation suggests that in the absence of the population effect, land in farms decreased by 997.5 acres per year but that population effects partially offset the decline.

Average size of farms is projected using the identity shown in Section IV of Table F-2.

The equation which describes the historical relationship of assessed value of farm land and buildings (VFLB) and is used to project expected values is presented in the agricultural sector of Table F-2. County dummy variables (D1, D2, and D3) were employed as indicators of land productivity and expectations for future economic conditions. The remainder of the equation suggests that VFLB is negatively related to population density (PDM) and positively related to time (T) in the Primary Area. Ignoring the effects of PDM and T the equation further suggests that VFLB is positively related to changes in non-farm earnings. Average value of farm land and buildings is calculated directly by dividing VFLB by land in farms (LF).

E. Business Activity Sector. Projected retail sales (RS) in the Primary Area were estimated from their historical relationship to disposable income (DY) as shown by the RS equation in Table F-2. After adjustments for county variations in retail sales, the RS relationship indicates that the marginal propensity to purchase from disposable income is approximately 0.18, implying that a one dollar increase in disposable income in the Primary Area will increase retail sales by $0.18.

Projected bank deposits (BD) were derived using the historical relationship as shown in Section V of Table F-2. As expected, the equation indicates that bank deposits are positively correlated to DY and BI.

F. Real Estate Sector. The first equation in Section VI of Table F-2 describes the historical effect of real estate valuation (REV) and time (T) on total assessed property valuation (APV). This equation indicates that the total value of real estate and personal property is positively related to both REV and T. Values of the dummy variables eliminate the effects of size variances among the Primary Area counties.

Projected real estate valuation per square mile (REM) is estimated based on its historical relationship with lagged REM (REM-1), population density (PDM), and time (T) as indicated by the equation in the real estate sector of Table F-2. The market value of real estate is determined by the demand of all potential buyers and the supply of all potential sellers. The supply of real estate is very inelastic. The demand schedule of all buyers depends upon the prices of real estate, the expected population density, income, real estate characteristics, and expected future economic conditions. The dummy variables, one for each county, are employed in the above stochastic equation as indicators of the nonquantifiable variables such as real estate characteristics, tastes of buyers, and expectations for future economic conditions. The remaining variables explicitly determine the direction and magnitude of change in REM which can be quantified. The above equation suggests the REM is positively related to lagged REM and time in the Primary Area but, ignoring these two variables, suggests that REM has been inversely related to population density (PDM).

The two components of total assessed property valuation, real estate valuation and personal and public service valuation, are estimated using the identities shown in Section VI of Table F-2.

G. Government Revenues. The historical relationship between retail sales tax, retail sales, and time is represented by the first equation in Section VII of Table F-2. The coefficient of retail sales (RS) suggests that, ignoring the effects of intercounty differences and time, a one dollar increase in retail sales will produce a $.036 increase in sales tax revenues. The time variable (T) is an indicator of changes in the structure of sales taxes and the composition of retail sales.

Projected levels of federal income taxes (FIT) are estimated from the second equation in Section VII of Table F-2. The explanatory variable for FIT, personal income (PY) is positively related to FIT and its coefficient suggests that the net marginal rate of federal income taxation in the Primary Area is 3.96 per cent, after adjustments for intercounty differences.

State personal income tax revenues (SPT) from the Primary Area are also projected from their relationship to personal income (PY). The coefficient of PY shown in Table F-2 has the same interpretation as for FIT, i.e. the net marginal rate of state income taxation.

Table F-1

LIST OF ECONOMIC VARIABLES

APV	Total Assessed Property Valuation ($1000)
ASF	Average Size of Farms: Total Acres divided by the number of farms
AVLB	Average Value of Land and Buildings per farm acre
BD	Bank Deposits
BI	Index of General Business (12 leading indicators prior to reverse trend adjustment)
D_1	Dummy for Monroe County
D_2	Dummy for Mahaska County
D_3	Dummy for Wapello County
DY	Disposable Income ($1000)
EM	Employment
FIT	Federal Income Tax ($1000)
FY	Farm Income
LF	Land in Farms: Total number of acres listed as agricultural land
NF	Number of Farms
PDM	Population Density per square mile
POP	Population
PRY	Proprietor, Property and Profit Income ($1000)
PSV	Personal Property and Public Service Valuation
PY	Personal Income ($1000)
REV	Real Estate Valuation
REM	Real Eatate Value per square mile ($8000)
RS	Retail Sales
SPT	State Personal Tax, except federal income tax ($1000)
ST	Sales Tax ($1000)
T	Time
TLF	Total Labor Force
UR	Unemployment Rate
VFLB	Value of Farm Land and Buildings ($1000)
WR	Real Wage Rate
WS	Wage and Salary Income
WS-1	Lagged WS

TABLE F-2

EQUATIONS OF THE PRIMARY AREA ECONOMETRIC MODEL

I. POPULATION SECTOR

$$\mathrm{LOG(PDM)} = 12.2118\ D_1 + .0968\ D_2 + .2585\ D_3 + .612598[\mathrm{LOG(PDM)}-1] - .003694\ \mathrm{LOG\ (PY)} - 3.543753\ \mathrm{LOG\ (T)}$$

II. LABOR FORCE AND EMPLOYMENT SECTOR

$$\frac{\mathrm{TLF}}{\mathrm{POP}} = .016054\ D_1 - .008625\ D_2 - .002253\ D_3 + 1.01477068\ \frac{\mathrm{EM}}{\mathrm{POP}}$$

$$\mathrm{EM} = -3964.5\ D_1 + 79.0\ D_2 - 244.1\ D_3 + .969690\ \mathrm{TLF} - .267611\ \mathrm{BI} + 1.981279\ \mathrm{T}$$

$$\mathrm{UR} = (\mathrm{TLF} - \mathrm{EM})/\mathrm{TLF}$$

$$\mathrm{WR} = \mathrm{WS}/(\mathrm{EM} \times 2000)$$

III. INCOME SECTOR

$$\mathrm{PY} = \mathrm{WS} + \mathrm{PRY} + \mathrm{TR} - \mathrm{SI}$$

$$\mathrm{WS} = -35995\ D_1 + 23840\ D_2 + 121849\ D_3 + 1.110244\ \mathrm{EM} + 432.153857\ \mathrm{BI}$$

$$\mathrm{PRY} = -21687\ D_1 + 2647\ D_2 - 17569\ D_3 + 210.842717\ \mathrm{BI} + .718049\ \mathrm{RS}$$

$$\mathrm{DY} = \mathrm{PY} - \mathrm{FIT} - \mathrm{SPT}$$

IV. AGRICULTURAL SECTOR

$$\mathrm{NF} = 84.4\ D_1 + 157.1\ D_2 + 49.6\ D_3 + .95035\ \mathrm{NF}_{-1} - .02634\ \mathrm{AVLB} - .00918\ \mathrm{FY}$$

$$\mathrm{LF} = 2211763\ D_1 + 96818\ D_2 - 16547\ D_3 + .392649\ \mathrm{POP} - 997.552751\ \mathrm{T}$$

$$\mathrm{ASF} = \mathrm{LF}/\mathrm{NF}$$

$$\mathrm{VFLB} = -619480\ D_1 + 15944\ D_2 + 8432\ D_3 - 164.775233\ \mathrm{PDM} + .066531\ \mathrm{WS}_{-1} + 321.138136\ \mathrm{T}$$

$$\mathrm{AVLB} = \mathrm{VFLB}/\mathrm{NF}$$

TABLE F-2 (continued)

EQUATIONS OF THE PRIMARY AREA EXONOMETRIC MODEL

V. BUSINESS ACTIVITY SECTOR

$RS = 18455.7\ D_1 + 37751.7\ D_2 + 66658.0\ D_3 + .183512\ DY$

$BD = -156382 + .092343\ DY + 3159.529302\ BI$

VI. REAL ESTATE SECTOR

$APV = -321911\ D_1 + 8567\ D_2 + 14381\ D_3 + .861446\ REV + 168.84053\ T$

$$LOG(REM) = -14.5399\ D_1 + .034522\ D_2 + .062539\ D_3 + .946361\ LOG(REM_{-1}) - .044919\ LOG(PDM) + 4.459939\ LOG\ (T)$$

$REV = REM \times$ Square miles

$PSV = APV - REV$

VII. GOVERNMENT REVENUES

$ST = -48588\ D_1 - 793\ D_2 - 1125\ D_3 + .036434\ RS + 24.547334\ T$

$FIT = 1060\ D_1 + 2708\ D_2 + 7984\ D_3 + .039658\ PY$

$SPT = -362\ D_1 - 819.6\ D_2 - 2121\ D_3 + .021767\ PY$

VIII. EXOGENOUS VARIABLES

(POP)	"Without OGS" Population
(TR)	Transfer Payments
(SI)	Personal Contribtuions to Social Insurance
(FY)	Farm Income
(BI)	Business Index
(T)	Time

APPENDIX G

ECONOMIC DATA

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G-2 Primary Area Employment by Economic Sector, 1950-1970
G-3 Public Facilities and Services - Ottumwa, Iowa
G-4 Primary Area - Projected Economic Activity with OGS

TABLE G-1

SELECTED STATISTICS FOR THE STATE OF IOWA

	Population (a)			Income per Capita		Personal Income Tax(c)	
	State Total #	Primary Area % Total State	State Density #/mi^2	State Total 1981$	Primary Area % Total State	State Total 1981$(000)	Primary Area Total State %
1950	2,625,000	3.4	46.6	3,763	66.4	41,131	4.2
1955	2,712,000	3.0	48.2	3,618	87.5	50,374	3.1
1960	2,758,000	2.9	49.0	3,994	94.5	73,843	2.6
1965	2,758,000	2.9	49.0	5,171	91.2	105,603	2.8
1970	2,824,000	2.6	50.2	5,781	95.8	231,554	1.7
1974	2,890,000	2.6	51.3	5,967(b)	97.8	447,159	2.1

(a) U.S. Bureau of Census, Current Population Projections, Series P-25

(b) Values obtained from U.S. Commerce Department Survey of Current Business, (Value shown for 1974 is a 1973 preliminary from the April 1974 issue)

(c) State of Iowa, Department of Revenue, Individual Income Tax, Annual Statistical Report, 1950-1974, Research and Statistics Division

TABLE G-2

PRIMARY AREA EMPLOYMENT BY ECONOMIC SECTOR
1950 - 1970(a)

Sector	1950	Per cent of Total State	1960	Per cent of Total State	1970	Per cent of Total State
Agriculture	7,074	23.1	4,650	16.6	2,694	10.2
Mining	469	1.5	209	0.7	73	0.3
Construction	1,455	4.8	1,526	5.4	1,174	4.4
Manufacturing	6,787	22.2	6,935	24.7	6,521	24.7
Finance	566	1.9	754	2.7	790	3.0
Services	4,930	16.1	5,668	20.2	6,952	26.3
Public Administration	866	2.8	775	2.8	874	3.3
Transportation	2,797	9.1	2,169	7.7	1,576	6.0
Wholesale Trade	1,040	3.4	943	3.4	811	3.1
Retail Trade	4,615	15.1	4,446	15.8	4,979	18.8
Total	30,599		28,075		26,444	

(a) Source: U.S. Census of Population, 1950 - 1970, Bureau of Census, 1970

TABLE G-3

PUBLIC FACILITIES AND SERVICES
OTTUMWA, IOWA

Rail Service	Burlington Northern, Milwaukee Road, Rock Island, Norfolk and Western
Air Service	Ozark
Bus Service	Continental Trailways, Greyhound, Missouri Transit (Also local intra-city line)
Truck Service	62 common carriers serve city through 12 terminals
Taxi	2; 5 cabs
Utilities	Electric, gas, water, wastewater, telephone
Banks	3
Savings and Loan	2
Hotels and Motels	570 rooms
Civic Clubs and Service Organizations	24
Churches	67
Schools	
Public	20
Parochial	0
Teachers	379
Libraries	1; Approx. 110,000 volumes
Colleges	Ottumwa Heights, 2 year; Indian Hills Community College
Hospitals	2; 368 beds plus 3 nursing-convalescent homes
Health Clinics	4
Doctors	20 GP's, 5 Surgeons, 20 Specialists
Dentists	13

TABLE G-3 (continued)

PUBLIC FACILITIES AND SERVICES
OTTUMWA, IOWA

Recreational Facilities	11 parks, 5 swimming pools, 3 tennis courts, 2 golf courses (18 holes), 3 bowling alleys, 3 ice rinks, one roller rink, boating, fishing, hunting, spectator sports
Law Enforcement	32 police officers, 7 cars and 2 cycles
Fire Protection	41 full-time personnel, 2 fire stations

TABLE G-4

PRIMARY AREA
PROJECTED ECONOMIC ACTIVITY WITH OCS
(Direct and Indirect Impacts in Parentheses)

Year	Population No.	Population Density No./Sq Mi	Total Labor Force No.	Employment No.	Unemployment Rate per cent	Personal Income $1000
1975	76,774	53.2	31,222	29,849	4.4	464,412
1976	77,238(90)	53.5(0.1)	32,006(208)	30,620(208)	4.3(-0.1)	475,532(4,867)
1977	77,761(240)	53.9(0.2)	32,919(545)	31,520(545)	4.2(-0.1)	489,667(12,750)
1978	78,697(802)	54.5(0.6)	34,197(1,247)	32,785(1,247)	4.1(-0.2)	512,331(29,161)
1979	79,400(1,132)	55.0(0.8)	35,381(1,854)	33,956(1,854)	4.0(-0.3)	532,798(43,376)
1980	79,062(420)	54.8(0.3)	35,325(1,222)	33,887(1,222)	4.1(-0.1)	524,262(28,587)
1981	79,165(150)	54.8(0.1)	34,747(68)	33,296(68)	4.2	503,525(1,598)
1985	80,660(150)	55.9(0.1)	37,048(64)	35,545(64)	4.1	528,434(1,497)
1990	82,528(150)	57.2(0.2)	39,929(64)	38,362(64)	3.9	559,696(1,497)
1995	84,395(150)	58.4(0.1)	42,810(64)	41,178(64)	3.8	590,958(1,497)
2000	86,263(150)	59.7(0.1)	45,691(64)	43,994(64)	3.7	622,220(1,497)
2005	88,131(150)	61.0(0.1)	48,572(64)	46,810(64)	3.6	653,482(1,497)
2010	89,999(150)	62.3(0.1)	51,454(64)	49,627(64)	3.6	684,744(1,498)

TABLE G-4 (continued)

PRIMARY AREA
PROJECTED ECONOMIC ACTIVITY WITH OCS
(Direct and Indirect Impacts in Parentheses)

Year	Wages & Salaries $1000	Profit and Proprietor Income $1000	Disposable Income $1000	Transfer Payments $1000	Contributions To Social Insurance $1000	Real Wage Rate $/Hr
1975	243,826	175,285	426,041	61,888	16,597	4.08
1976	250,962(4,169)	177,894(698)	436,477(4,568)	63,947	17,272	4.10(.04)
1977	260,454(10,704)	181,153(2,046)	449,743(11,966)	66,006	17,946	4.13(.10)
1978	277,700(24,993)	185,186(4,168)	471,015(27,369)	68,065	18,621	4.24(.23)
1979	293,146(37,482)	188,823(5,894)	490,225(40,711)	70,124	19,295	4.32(.34)
1980	283,311(24,689)	188,738(3,898)	482,214(26,832)	72,183	19,970	4.18(.22)
1981	262,913(1,334)	187,014(263)	462,750(1,500)	74,242	20,645	3.95(.01)
1985	274,719(1,312)	194,580(185)	486,129(1,405)	82,478	23,343	3.86(.01)
1990	289,505(1,312)	204,135(185)	515,471(1,405)	92,772	26,716	3.77(.01)
1995	304,291(1,312)	213,689(185)	544,812(1,404)	103,067	30,089	3.70(.02)
2000	319,077(1,312)	223,244(185)	574,154(1,405)	113,361	33,462	3.63(.01)
2005	333,863(1,312)	232,799(185)	603,496(1,405)	123,656	36,835	3.57(.01)
2010	348,649(1,312)	242,353(185)	632,838(1,406)	133,950	40,208	3.51(.01)

TABLE G-4 (continued)

PRIMARY AREA
PROJECTED ECONOMIC ACTIVITY WITH OGS
(Direct and Indirect Impacts in Parentheses)

Year	Federal Income Taxes $1000	State Income Taxes $1000	Business Index No.	Retail Sales $1000	State Sales Taxes $1000	Assessed Property Valuation $1000
1975	32,290	6,082	133.4	237,961	6,432	172,702
1976	32,731(193)	6,324(106)	135.2	240,009(971)	6,580(35)	182,957(5,621)
1977	33,292(506)	6,632(278)	137.0	242,963(2,849)	6,761(104)	216,861(34,724)
1978	34,190(1,156)	7,125(635)	138.8	246,996(5,805)	6,982(212)	231,556(44,444)
1979	35,002(1,720)	7,571(945)	140.6	250,476(8,208)	7,182(299)	236,712(44,444)
1980	34,664(1,133)	7,385(622)	142.2	248,774(5,429)	7,194(198)	242,054(44,444)
1981	33,841(63)	6,933(34)	144.2	244,789(367)	7,122(13)	247,590(44,444)
1985	34,829(59)	7,476(33)	151.4	248,987(257)	7,570(10)	271,826(44,444)
1990	36,069(60)	8,156(32)	160.4	254,372(258)	8,134(9)	307,457(44,444)
1995	37,309(60)	8,837(33)	169.4	259,757(258)	8,699(10)	350,150(44,444)
2000	38,548(59)	9,517(32)	178.4	265,141(258)	9,263(9)	401,361(44,444)
2005	39,788(59)	10,198(33)	187.4	270,526(258)	9,827(9)	462,853(44,444)
2010	41,028(59)	10,878(32)	196.4	275,910(257)	10,392(10)	536,751(44,444)

TABLE G-4 (continued)

PRIMARY AREA
PROJECTED ECONOMIC ACTIVITY WITH OCS
(Direct and Indirect Impacts in Parentheses)

Year	Real Estate Valuation $1000	Real Estate Value Per Sq. Mile $1000/Sq Mi	Personal & Public Service Valuation $1000	Farm Income $1000	Avg. Assessed Value of Farm Land & Buildings $/Acre	Assessed Value of Farm Land & Buildings $1000
1975	133,622	92.5	39,080	39,417	67.3	56,229
1976	139,866(1,453)	96.9(1.0)	43,091(4,168)	39,636(-126)	70.7	58,847
1977	144,852(1,453)	100.3(1.0)	72,009(33,271)	39,982(-126)	72.5(0.3)	60,153(278)
1978	150,039(1,453)	103.9(1.0)	81,517(42,991)	40,327(-126)	74.5(0.8)	61,616(712)
1979	155,435(1,453)	107.6(1.0)	81,277(42,991)	40,672(-126)	77.2(2.0)	63,595(1,663)
1980	161,049(1,453)	111.5(1.0)	81,005(42,991)	41,018(-126)	79.7(3.0)	65,454(2,494)
1981	166,887(1,453)	115.6(1.0)	80,703(42,991)	41,363(-126)	80.2(2.0)	65,631(1,643)
1985	192,670(1,453)	133.4(1.0)	79,156(42,991)	42,745(-126)	84.5(0.1)	68,188(87)
1990	231,091(1,453)	160.0(1.0)	76,366(42,991)	44,472(-126)	92.5(0.1)	73,329(88)
1995	277,711(1,453)	192.3(1.0)	72,439(42,991)	46,198(-126)	100.8(0.1)	78,469(87)
2000	334,219(1,453)	231.4(1.0)	67,142(42,991)	47,925(-126)	109.4(0.1)	83,610(87)
2005	402,661(1,453)	278.8(1.0)	60,192(42,991)	49,652(-126)	118.4(0.2)	88,751(88)
2010	485,505(1,453)	336.2(1.0)	51,246(42,991)	51,379(-126)	127.6(0.1)	93,891(87)

TABLE G-4 (continued)

PRIMARY AREA
PROJECTED ECONOMIC ACTIVITY WITH OGS
(Direct and Indirect Impacts in Parentheses)

Year	Land in Farms Acres	Number of Farms No.	Average Size of Farms Acres	Bank Deposits $1000
1975	835,206	3,604	231.7	304,441
1976	832,360	3,516(1)	236.7(- 0.1)	311,091(421)
1977	829,514	3,428(2)	242.0(- 0.1)	318,004(1,105)
1978	826,668	3,342(3)	247.4(- 0.2)	325,655(2,527)
1979	823,822	3,256(4)	253.0(- 0.3)	333,116(3,759)
1980	820,976	3,172(5)	258.8(- 0.4)	338,064(2,478)
1981	818,130	3,088(6)	264.9(- 0.5)	341,953(138)
1985	806,746	2,762(9)	292.1(- 0.9)	366,861(130)
1990	792,517	2,370(12)	334.4(- 1.7)	398,006(130)
1995	778,287	1,991(14)	390.9(- 2.8)	429,151(129)
2000	764,057	1,623(17)	470.8(- 4.9)	460,297(130)
2005	749,827	1,262(18)	594.2(- 8.6)	491,442(130)
2010	735,597	907(19)	811.0(-17.4)	522,587(130)